

electric & hybrid

vehicle technology international

January 2020

HOT ISSUE

The crucial role advanced thermal
management will play in delivering
the next generation of battery
and charging technologies



PAY IT FORWARD

Why vehicle-to-grid infrastructure is the smart solution to support utilities for the drastic impact of electrification

GREASE THE WHEELS

Faced with changing times, oil companies are tapping into new opportunities with specially-developed lubricants for e-motors

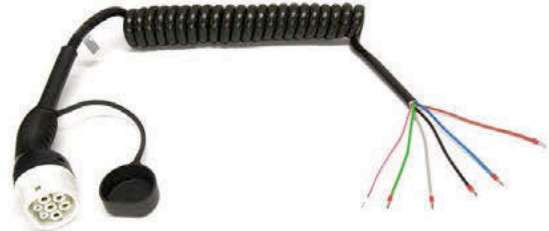
THE FUTURE OF LITHIUM-ION

Multi-million dollar research projects are discovering ways to revolutionize battery performance and production

DUTCH ELECTRICAL DRIVING SOLUTIONS



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JANUARY 2020



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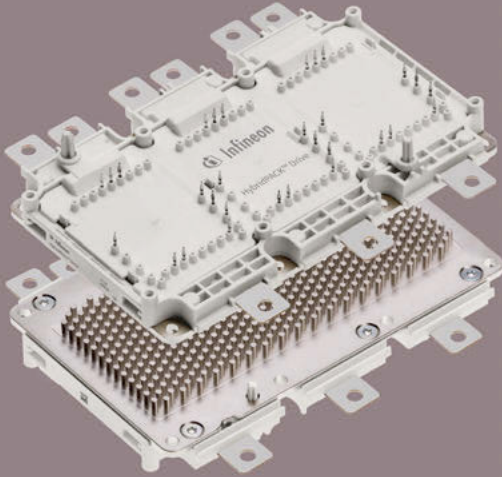
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Infineon introduces HybridPACK™ Drive Performance

Automotive-grade power modules with best-in-class efficiency bring electric mobility to the next level

Infineon's HybridPACK™ Drive is a power module with a six-pack configuration for use in 3-phase xEV inverters. The new performance products within the HybridPACK™ Drive product family target main inverter powers in the range up to 175 kW. The modules can be integrated into the most common types of battery systems in the 400 V and 800 V ranges.

HybridPACK™ Drive Performance is based on Infineon's most advanced IGBT technology, which offers best-in-class performance together with outstanding reliability. The platform design of HybridPACK™ Drive Performance supports scalability across the 100 kW to 175 kW inverter output power range thanks to various baseplates and ceramics.

Infineon's HybridPACK™ Drive is one of the most commonly used power modules in the market. Combining this experience with Infineon's system expertise leads to benchmark automotive-quality products. Infineon's production capacity enables customers to bring scalable inverter platforms rapidly to market.



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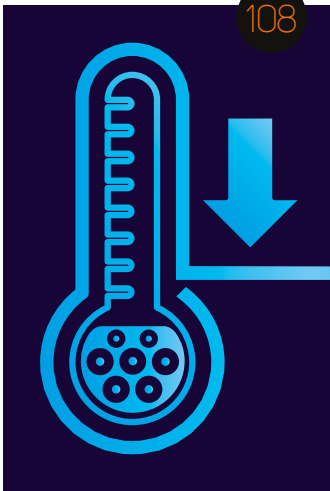
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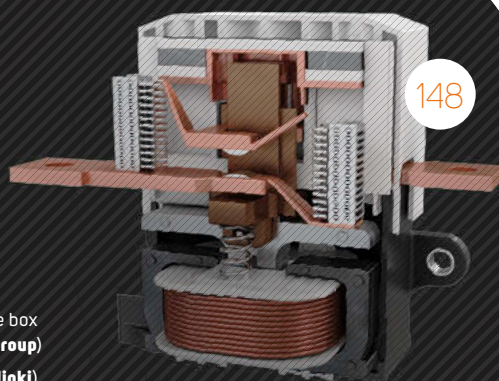
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EDITOR'S NOTE

It's funny how history repeats itself. To the majority of consumers, electrification of passenger vehicles might seem like the becoming of a nascent technology but, in reality, it's not an invention of modern times at all. Those in the industry will know that the first examples of the technology appeared as far back as the early 19th century and were well on their way to widespread adoption in the early 1900s, until the combination of Henry Ford and big oil put a halt to that. Over 100 years later, through both necessity and design, we're back at seeing the boom of battery power back on the roads.

So, are we at tipping point? Every OEM we've ever talked to has spoken of the wish to see the moment when the adoption of an electric powertrain isn't a novel choice, but an organic one. I believe we have.

I think a good measure of when a technology is beyond the conversation of adoption is when there are people already looking at ways to make it better. Take our cover story, for example. The debate over the move to electric power is no longer in question, rather it's how, at component level, such as battery cells and thermal management, improvements can take it to the next level. With the introduction of 350kW high power charging from the likes of Ionity, we're already using capacities over 100-times that of typical chargers. All this in just a few years. However, it takes new technology to push the industry forward, which is why thermal management is such an important topic to unlock further developments.

Colleagues, friends, family and even strangers I talk to are quick to tell me about the new EV they're driving or plans to buy one – all this has come about from an amalgamation of factors, starting from the enforcement of CO₂ emissions

targets, to OEMs investing in technology to create vehicles to meet these, and offering more choice for consumers at attractive prices. Yet, there is always that one type of person I meet who is desperate to poke holes in battery power. This person loves their diesel car because it's cheap and efficient, selfishly oblivious to the fact it's using a fuel source that is finite and choking the planet. They cite emission levels in EV production, ignorant to the fact many OEMs are operating carbon-neutral plants and charging networks use renewable energy. Then they regurgitate tabloid headlines about EVs 'spontaneously' bursting into flames. Of course, with the need for faster charging comes the handling of more energy but clever thermal solutions and battery packaging is taking out any risks, which are overblown. Besides, the safety of battery power against internal combustion is almost incomparable.

As a well-known engineer rightly pointed out to me: "Why are we still debating the comparisons in safety of electric vehicles against combustion engines? If internal combustion was invented today, it would never pass safety regulations. And if it somehow did, could you imagine trying to convince consumers to drive a vehicle powered by a highly flammable liquid effectively being set alight inches away from their seat? So why are consumers so concerned with battery safety?"

This year we will see the rollout of new electrified fleets with more full-electric or hybrid models on sale than ever. Tipping point has arrived, so simplistic doubts over safety or environmental benefit now need to disappear as quickly as the emissions from that diesel owner's tailpipe.

James Billington

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Reality bytes

Byton will begin customer deliveries of its first production car in 2020; a highly-connected luxury electric SUV for the world's most demanding markets, born out of a fast-paced global development program

WORDS: ALEX GRANT





VITAL STATISTICS

Motors: 200kW/272hp (rear), 150kW/204hp (front, optional) with single-speed transmission

Peak power: 200kW/272hp (RWD), 300kW/408hp (AWD)

Battery: Liquid-cooled lithium-ion, 72kWh/95kWh capacity

Charging: 7kW (China) or 11kW AC (North America and Europe) with 22kW optional. 150kW DC (GBT/CCS)

Range (WLTP): 360km/224 miles (72kWh RWD), 435km/270 miles (95kWh AWD), 460km/286 miles (95kWh RWD)

Body: Steel/aluminum composite

Weight: 2,315-2,600kg (5,104-5,732lbs)

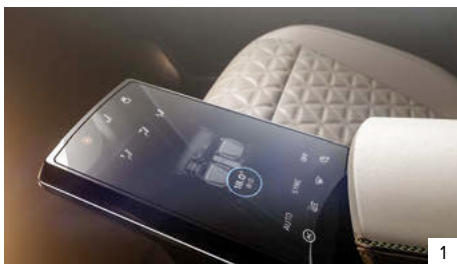
For emerging Chinese OEM Byton, actions speak louder than words. Pre-production of the M-Byte electric SUV has started in Nanjing in October 2019, earmarked for launches in China, Europe and North America within 12 months. Just over three years previously the company didn't exist.

"This is happening very, very fast," the company's chief technical officer, David Twohig describes. "The time between putting the first piece of steel in the ground [in Nanjing] and building the first production [tooled] bodies was 325 days. If you told me we were going to do that two years beforehand, I would not have believed you myself."

Twohig joined the company in March 2018 following a notable career within the Renault-Nissan-Mitsubishi Alliance, with responsibility for projects including the first Nissan Qashqai, Renault Zoe and Alpine A110 sports car. Byton's headcount has expanded more than five-fold since, now comprising 1,600 employees with sites in California, Germany and China.

Most of the foundations were already in place. The M-Byte is based on Byton's own Smart EV platform, which will also underpin a forthcoming sedan and MPV. Its battery pack is beneath the cabin, providing a flat floor with motors at one or both axles, while the aerodynamic body features the same closed front end and retracting door handles from the 2018 Consumer Electronics Show concept car.

The battery pack is its backbone, claims Twohig, and was designed in-house to meet the project's ride, handling



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1. Touchscreen controls remove physical buttons within the cabin

2. The M-Byte has undergone an extensive global testing program

3. A tech-laden interior features a 48in HD dash display and steering wheel display

4. David Twohig, Byton's chief technical officer

and crash safety requirements. It comprises an aluminum tray manufactured by Constellium, containing CATL modules which are liquid-cooled to enable DC charging at up to 150kW via either a CCS or GBT connector. CATL's relationship with Byton was so close that they have since become a shareholder.

Twohig's role was to deliver the claimed 90% transfer of the concept into a production reality and, as a relatively small manufacturer, close supplier partnerships enabled Byton's own engineers to focus on systems where there was no market solution available. For example, the cabin materials were co-developed with Faurecia, but the graphics processors behind the shatter-proof 48in dashboard display were bespoke, developed in-house.

"We are not an EV maker who thinks we can do everything better in house than everybody else," he continues. "We're trying to take the best of the traditional car industry, and combine that with the best of Silicon Valley and China. There are truly world-class suppliers out there, who have been in the business for a long time and understand the challenges of EV startups. We're happy to work with them and have them as partners."

Bold moves

Visual changes couldn't always be avoided. Euro NCAP pedestrian safety requirements resulted in a raised bonnet line, and the production car features conventional mirrors instead of cameras. Twohig attributes the latter to "negligible" aerodynamic gains versus the cost of legally-required

additional screens in positions on the door card or A-pillar. These could, he says, be added later.

The first of around 100 attribute prototypes began road testing in August 2018, assembled at the Nanjing plant less than 11 months after the plant broke ground, and Twohig says a lot of the "miles-intensive" validation work was done within China. This offers a uniquely broad selection of terrain and climate testing conditions, from -30°C (-22°F) in Inner Mongolia, to hot weather testing in the Gobi Desert, and world-class test facilities including CATARC in Tianjin. Byton also now has its own R&D center in the country.

However, this was a global project, with prototypes shipped to Germany for validation of chassis and driver assistance systems with Bosch, South Korea with Mando, and additional hot and cold weather testing in the United States. There are no plans for market-specific chassis calibrations, though digital content will vary – Chinese versions will be based on the Baidu OS, while North America and Europe will use Amazon's Alexa instead.

Rapid advances in development didn't go unnoticed. "When you're in an EV startup, and nobody knows who you are, you start by selling the company to the vendor base. You're convincing these guys that you're going to exist, and that you want to build cars one day," recalls Twohig.

"From 2018 I saw suppliers become convinced that we are for real. That relationship changed very quickly, in the space of around six to eight months, from us having to convince vendors to supply parts to us, to [them] knocking on the door saying they would like to do business with Byton."

Customer deliveries are scheduled to begin in 2020, and Twohig says the company is fine-tuning pre-production models ready for series manufacture – the Nanjing plant has a 300,000-unit annual capacity.

"Fine tuning is what makes a premium car, and we will continue to polish it and continue to refine it until it's right – we will not put the car out half ready," he states. "Talk is cheap in this business, but when you walk the walk and you actually take [suppliers] around the plants, you can show them an off-tool production body with very, very good geometry built in our plant... that's worth a million PowerPoint slides." 



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O-Kei Computer

Nissan's IMk concept aims to clean up the city and the reputation of Japan's compact Kei car

WORDS: LEON POULTNEY

In Japan, the diminutive Kei car accounts for over one-third of domestic new car sales, despite the government increasing the taxation on this tiny example of personal transportation by some 50% in 2014.

Yet, Ivan Espinosa, corporate vice-president of Nissan, believes that there is an inherent problem with the popular Japanese machines, chiefly that they are flawed in many ways. "There are a lot of complaints from our customers that there is a distinct lack of power, they are often uncomfortable and quite noisy to drive," he revealed during a recent Q&A session at this year's Tokyo Motor show.

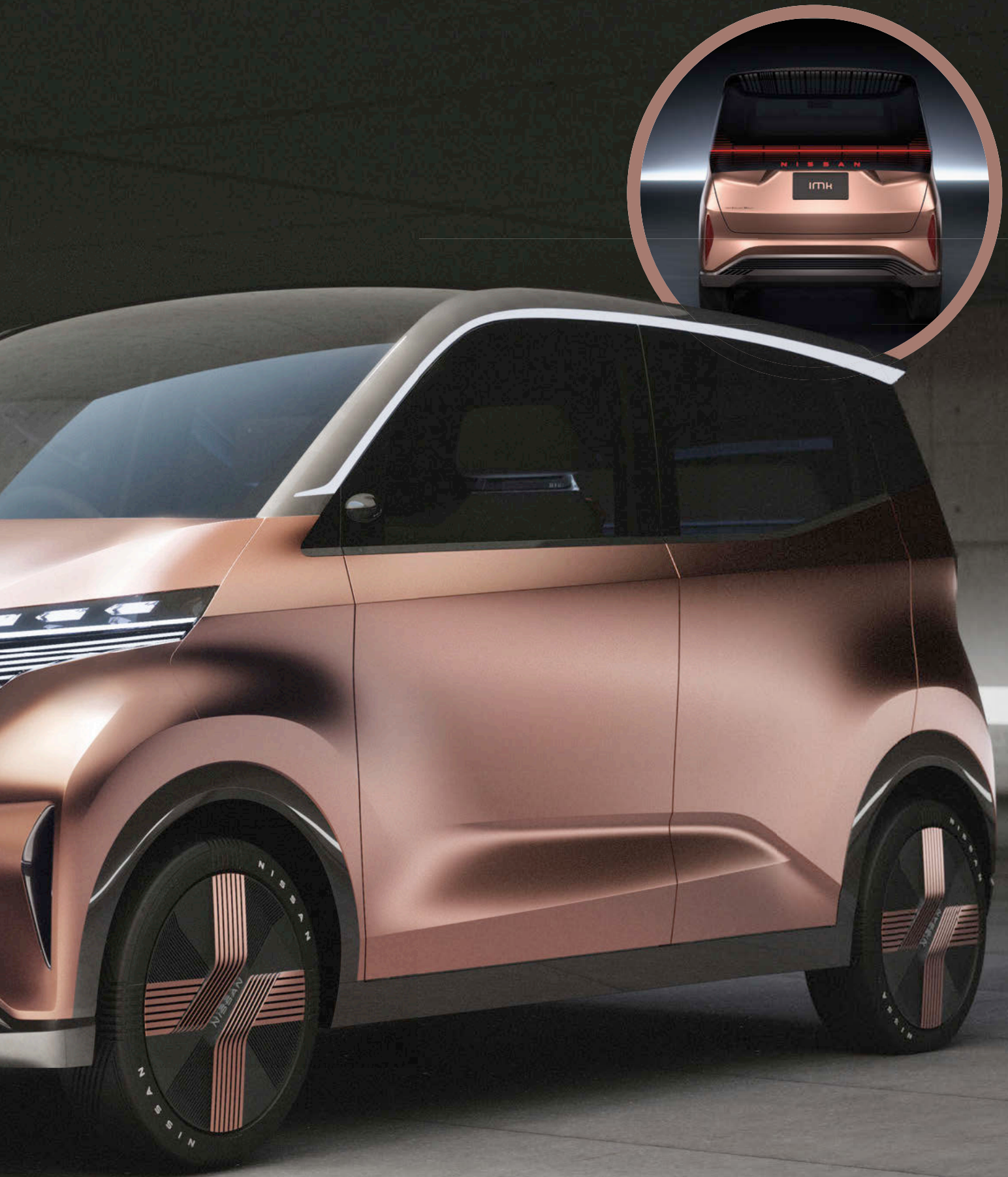
As a solution to this, Nissan took the wraps from a shimmering copper concept car at the show that the manufacturer believes will pave the way for a new generation of compact inner-

city transportation. Dubbed the IMk concept, the 100% electric vehicle measures just 3,434mm long and 1,512mm wide, with a roof height of 1,644mm.

Taller than it is wide, the IMk is the first to show off an all-new electric vehicle platform that the Japanese marque hopes will spawn a number of models (of various sizes) that will tackle the common issues of inner-city overcrowding and congestion, while simultaneously reducing emissions and noise by moving away from the internal combustion engine.

"We are confident that the IMk will be a game changer for the Kei car segment," says Makoto Fukuda, chief product specialist for EV and EV concepts. "Despite its small size, it feels like a large car inside and the most common complaint we find with customers is







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3

1. While the IMk concept's powertrain details have not been revealed, Nissan announced it is working on an electric-drive, all-wheel-control system

2. The cabin interior design aims to replicate a lounge or café and promote a sense of calm, with hidden lighting and soft carpeting

3. The car's dash and instrument panel is made from light upholstery and is void of physical controls

surrounding acceleration and performance. This new, hi-tech electric powertrain will address this," he adds.

Currently, there is no word on the amount of motors involved or the sort of range and performance figures we can expect from the IMk, but Japanese legislation states that maximum power output must be limited to 47kW (63hp), with current internal combustion engine models boasting a maximum displacement of just 660cc.

"This has been one of the key reasons why this segment of vehicle has failed to take off in Europe," Fukuda explains. "The 47kW output hasn't been satisfactory, but I think with the breakthroughs we are making with battery technology we will see much greater performance and potential access to new markets," he adds.

Built to withstand the rigors of everyday use, the boxy IMk concept makes the most of the flat floor provided by the upcoming electric vehicle platform. With the wheels pushed to the outer limits of each corner, it feels more like the lounge of a café or lounge inside.

"The IMk is a car for people who have never before considered buying a vehicle of this size," says Nissan executive design director Satoru Tai. "The electrification of this urban commuter, and the EV platform, elevate the

genre to a completely new level. It will capture a new market, such as luxury-car owners in Tokyo who want stylish exclusivity and great performance, yet still want to be able to find a place to park. The level of sophistication and chic textures is unmatched in the segment."

For the interior, there is liberal use of lightly colored fabrics, a bench seat at the rear and a deep-pile copper carpet that lines the floor. "The surfaces are treated with anti-soiling agents to prevent stains and fingerprints," explains Tai. "The lighter color, which isn't traditional for a car in this class, is very trendy in home interiors and cafés. We wanted to create that light and airy environment in the IMk, while keeping it durable."

Perhaps most importantly, a typical infotainment system is replaced with a prismatic instrument and display unit that runs across the width of the front dash.

The IMk shared a stage with a second concept vehicle, the Ariya, which is said to be a very close representation of Nissan's soon-to-be-released all-electric SUV. Its interior is far closer to something customers would expect from a production car today, but the two show cars both shared plenty of technology.

"Both the IMk and Ariya Concept have Pro Pilot 2.0, which will allow users to enjoy hands-off autonomous driving for the first time," says Fukuda. "This sort of technology is a huge improvement over the safety systems currently found in today's Kei cars. It has potential to move the game on."

It seems highly likely that we will see a production version of the Ariya before the compact IMk hits the market, but Nissan is furiously pushing ahead with its EV technology. As the Tokyo Motor Show wrapped up for another year, the Japanese marque revealed it was already experimenting with an electric-drive all-wheel-control system that would "take the performance of Nissan's electric cars to a new level".

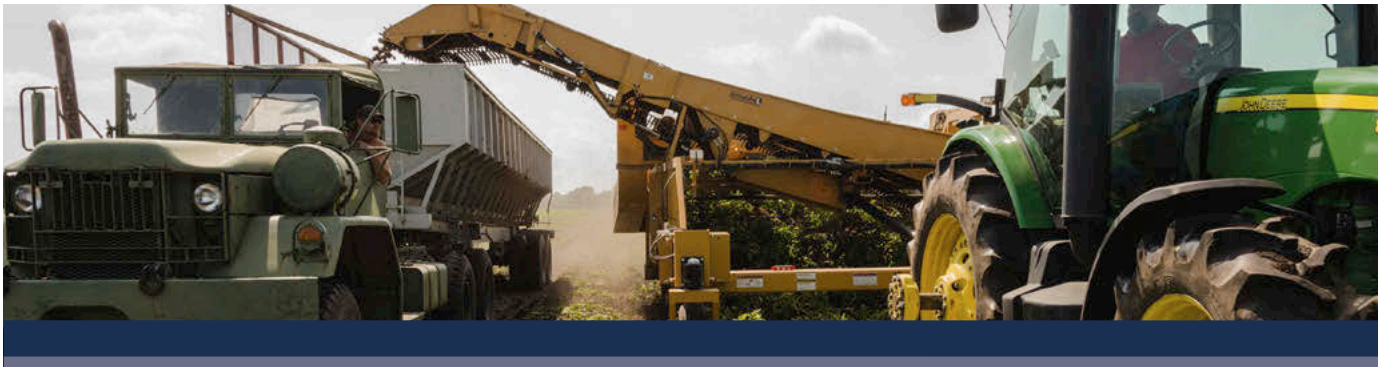
Does that mean we will see an upcoming sports car to add to the funky future line-up? Only time will tell. 

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- Charging Systems
- Commercial Ground Vehicles

APPLICATIONS:

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- Motor Control Circuit Isolation
- Circuit Protection
- Alternative Energy
- Energy and Battery Storage

RELIABLE:

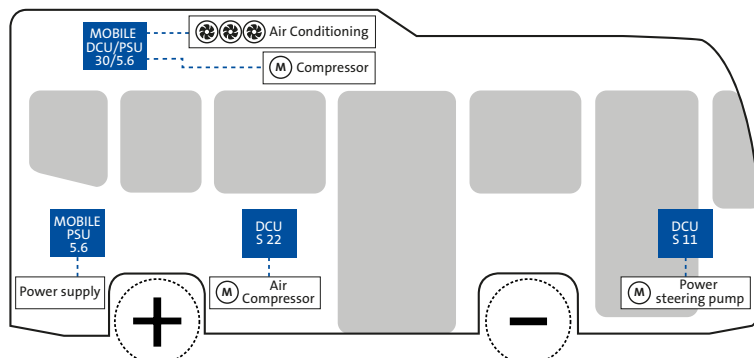
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- Increased rupture and dielectric capability



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Fast track

Founded less than two years ago, Chinese startup Aiways has begun the start of production of its electric SUV – an affordable alternative to the Tesla Model X and Audi e-tron

WORDS: ALEX GRANT



Chinese carmaker Aiways doesn't let the grass grow beneath its feet. It first previewed the U5 electric SUV in September 2019 ahead of production starting at its €1.7bn (US\$1.9bn) factory in Shangrao, China in December. Since then it has gone on to be the first Chinese electric vehicle manufacturer to attain Europe-wide type approval from TUV Rheinland.

Developed almost entirely in-house, not only was the 18-month process remarkably quick, but the business itself was months old when the project started. "We don't have a brownfield operation, everything is greenfield," explains Dr Alexander Klose, the company's executive vice president of overseas operations. "The car is designed as an electric vehicle, the plant is designed for manufacturing electric vehicles, and it's been optimized [for that]. We can just do it a better way."

Aiways now employs 1,000 staff, split between its headquarters in Shanghai, R&D center in Jiading, and the Shangrao plant. One new model per year is planned – larger and smaller SUVs will be first – with sales planned for every global market with "a certain propensity towards electric vehicles," Klose says.

"We have no engineers [in Europe], the car was designed and engineered in China, with global quality in mind," he explains. "The reason we can do that is the engineering team has an international background."



1. The U5 is an all-electric SUV built on a low-weight modular platform that removes unnecessary components to keep it just 1,730kg (3,813lbs)



2

2. Over 3.5 million kilometers of validation testing has been conducted

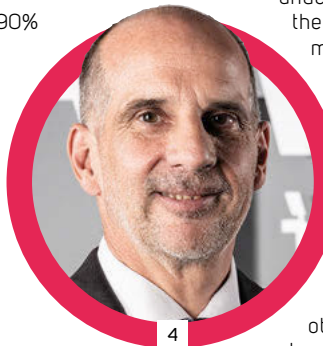
3. The U5 e-drive system produces 140kW of peak power and 315Nm torque

4. Dr Alexander Klose, director of overseas operations for Aiways

Low-cost, high-tech

Similar in footprint to a BMW X3, the U5 uses Aiways' own modular platform, prioritizing low weight and maximum interior space. The body-in-white comprises 52% aluminum and uses as few components as possible, while the patented paint process minimizes preparation steps, cutting waste by 90% and saving 3.6kg (8lbs) from the vehicle. Klose points out that the U5 weighs 1,730kg (3,813lbs), while similar products tip the scales at more than two tons.

The powertrain comprises a single-speed transmission, inverter and electric motor,



4

which produces 140kW peak power and 315Nm torque. With a 16,000rpm maximum speed, the motor is smaller and lighter than equivalent units, enabling the entire system to fit into a city car and to be used for front, rear and four-wheel drive applications. In the U5, it drives the front wheels.

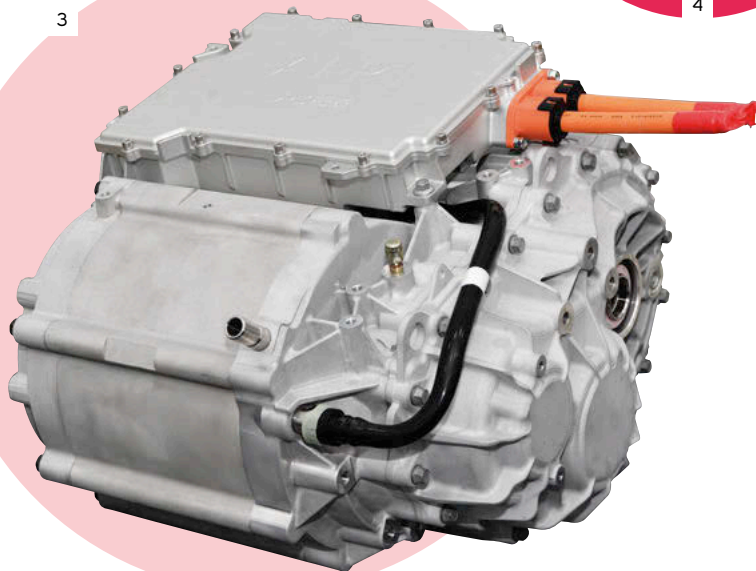
Launch models will feature a 63kWh battery, packaged under the cabin within reinforced sills. CATL supplies the cells and modules, but Klose says the thermal management system is Aiways' own. The pack is layered, separating the modules and cooling plate to reduce the potential for short-circuits if it is damaged, while a 15mm gap between the components and protective under-body panel insulates the cells from external conditions, minimizing seasonal variations in range.

The U5 offers a 460km (285 mile) NEDC range, helped by a low-drag body with a closed front end and retracting door handles. There are two vents below the headlights, one cooling the battery, the other hiding a CCS port offering 6.6kW AC and 60kW DC charging for Europe. A 36kWh variant, positioned beneath the target priced €30,000-35,000 (US\$33,000-39,000) launch model, is also under development.

Despite global ambitions, China's varied climate allowed all testing to be done within the company's home country. More than 150 prototypes have been built at Jiading, and Aiways is claiming 3.5 million kilometers of validation testing, including setting a Guinness World Record for the longest journey by an electric vehicle after driving 15,022 km (9,334 miles) on a route from China to Frankfurt, Germany. It has also tested submerging the battery in a meter of water for 24 hours, hot climate tests were completed last year, and cold testing is underway in Bei'an, northern China, reflecting a 300km (186 mile) real-world range in sub-zero temperatures.

"We wanted to live on a tight budget – we have a tight budget but we also wanted to avoid over-designing and over-engineering the vehicle," explains Klose. "It's been challenging every day but, because we are so new, we can do whatever we want. We don't have to take care of anything that's a legacy." 

3



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The big picture

Renault sees mainstream potential for its first-ever full hybrid system, with plans to offer it as a diesel alternative in its best-selling models, and plug-in versions in the pipeline too

WORDS: ALEX GRANT



Despite its early adoption of fully-electric technology, Renault hasn't overlooked the potential for hybridization. This year, the company's best-selling product, the Clio, will debut a full hybrid system which will also underpin plug-in versions of the Captur and Mégane shortly afterwards. With diesel demand declining and emissions compliance already pricing it out of some segments, the E-Tech system is seen as an important alternative.

Development began almost nine years ago, and was undertaken entirely in-house. More

than 150 patents were filed during the process, which principally benchmarked Toyota's Hybrid Synergy Drive but set out unique characteristics tailored to European customers, according to Renault hybrid engineer, Antoine Vignon.

"We wanted to make the hybrid as close as possible to an electric car. So we made a choice [at the start] to remove the clutch system and make all the take-off of the vehicle electric. That's very important, because you will have all the advantages of an EV – dynamic response, it's very quiet and you can generate a high level of acceleration," he explains.

The E-Tech system is based on a hybridized dog gearbox using two motor-generators. The larger of these is a permanent-magnet unit shared with Nissan, which is packaged in the transmission and provides power to the wheels via two gears - one enables fully-electric take-off, the other enables efficient assistance of the combustion engine available at the vehicle's maximum speed. A second, smaller, motor-generator is permanently connected to the engine, serving as the starter motor and maintaining battery charge, particularly while driving in traffic with power-hungry on-board systems running.

"We are able to use the e-motor power from [standstill] up to the maximum speed of the vehicle," Vignon continues. "With two speeds we are able to use the power of the e-motor, which is important when you are in hybrid mode because when you push the throttle you have all the advantages of the e-motor torque. When you are cruising on the highway you don't need the e-motor, so we are able to disconnect it and optimize the fuel consumption."

Driving conditions

Renault's first hybrids will use a 1.6-liter, naturally-aspirated gasoline engine, also sourced from Nissan. This has its own four gears, with ratios equivalent to third, fourth, fifth and sixth in a conventional transmission because the electric take-off negates the need for first or second. Gears are synchronized using the larger motor-generator and selected by an actuator, though drivers won't be able to select them manually. The system will automatically choose one of 15 configurations, optimizing engine efficiency, performance

1. In 2018, Renault revealed its K-ZE - an affordable, fully-electric vehicle to lead the company's charge into the EV market

2. Hybrid and plug-in hybrid models will use Renault's hybrid E-Tech engine with clutchless transmission and high power electric motor

3. Renault's strong electrification strategy will hybridize its best-selling model, the Clio, with the Mégane and Captur soon to follow

and regenerative braking to suit the driving conditions. Vignon says the transmission weighs around 10kg (22lbs) more than a dual-clutch unit, or 30kg (66lbs) more than a six-speed manual.

"Our target was to have all the advantages of serial hybrid and parallel hybrid driving," he explains. "At full throttle you will have the feel of a DCT. You will have a link between the ICE and the speed of the vehicle, which is very important. We also tried to have the advantage of the serial hybrid, in terms of smoothness and not having gear-changes when you are driving in the city. Compared to the benchmark we will have a very high reactivity level because the e-motor is connected directly to the wheels."

Similar to the Zoe, the controls are designed for simplicity. Driving modes are selected via a five-position cable-operated shifter, including a 'B' mode which increases regenerative braking. All E-Tech models will offer a selectable EV setting, depending on battery state of charge, and a Sport mode which combines gasoline and electric power sources. Plug-in hybrids will enable drivers to manually preserve electric range for later in the journey.

Drivetrain components are shared between hybrid and plug-in versions, with performance and electric range dictated by the lithium-ion battery pack located under the boot floor. The battery in the Clio hybrid has a capacity of 1.2kWh, an output of 230 volts and is air-cooled by a vent in the door jam. Renault claims this system will enable 80% of urban driving to be done only using battery power, offering a 40% reduction in fuel consumption and WLTP combined cycle CO₂ emissions of less than 100g/km.

Plug-in versions will feature a larger 9.8kWh battery, providing a 400-volt output and increasing system power to 162ps, compared to 142ps for the hybrid. A Type 2 AC charging port, located under a flap on the right-hand rear wing of the car, provides a 50km (31-mile) WLTP-derived electric range for the Captur, targeting CO₂ emissions of 32g/km. A hybrid-specific boot floor pressing removes the spare wheel well to make space for the battery pack, preserving the luggage capacity.

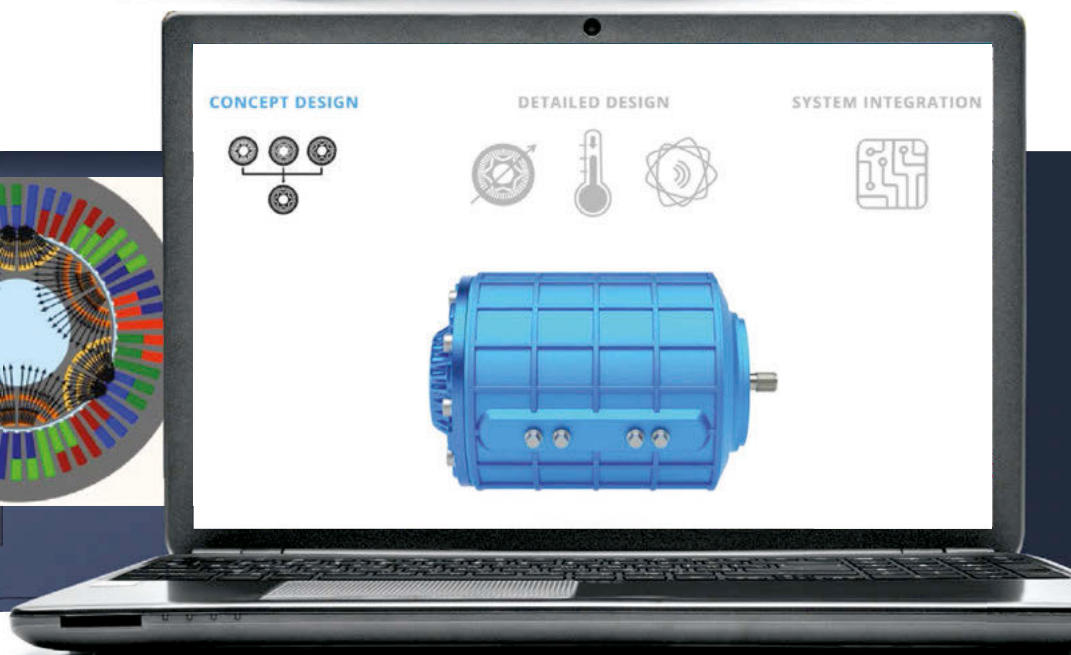
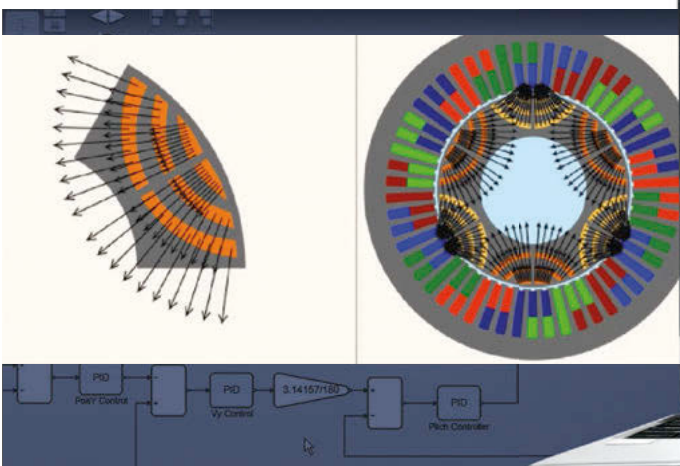
Vignon adds that there is flexibility to utilize the system in a wider range of products in future: "We are launching this technology in the B-segment because it is our best-seller, but obviously [it] is scalable to bigger cars with larger e-motors. There is no limitation," he concludes. 

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Special delivery

For Ford's first plug-in hybrid light commercial vehicle, the Transit Custom PHEV, development was shaped by real-world prototype fleet trials, close engineering cooperation and a need for maximum usability

WORDS: RICHARD GOODING





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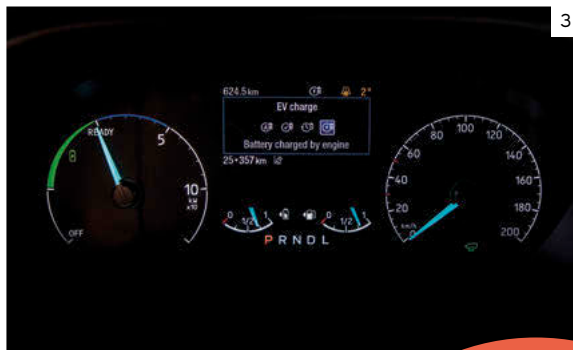
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1. Plug-in electric power for light commercial vehicles will enable companies to meet emissions targets being enforced in cities

2. A 1.0-liter Ecoboost engine is coupled with a 92.9kW electric motor for a combined range of 499km (310 miles)

3. Four driving modes control the available battery charge and levels of regenerative braking

4. Ford wanted to ensure there was no difference or compromise in internal space compared with the internal combustion-engined Transit



3

battery charge, and two levels of regenerative braking capture electrical energy.

Prototype development started in June 2016. Initiated at Ford's Duntun technical center, UK engineering group Prodrive Advanced Technology was involved in building prototypes for a Transport for London and Advanced Propulsion Centre-supported fleet trial program. "The first running prototype vehicles were at the LCV event in September 2017, just 15 months after the project started," states James McGeachie, engineering director at Prodrive Advanced Technology. "All 27 vehicles for the trials were delivered by March 2018, a timescale of 20 months from concept rendering to final delivery. Ford is now entering production, so it has effectively created a new vehicle platform in less than three years."

"Key to achieving such tight timescales was how closely and well Ford and Prodrive worked together," claims McGeachie. "We exchanged design data weekly so Ford could put our prototype design data into its production design process and see the effect of the requirements it put upon us almost in real time, and how it would affect its own production design. The senior Ford and Prodrive project teams met at Prodrive in Banbury every week to make key decisions on design direction."

Cars have lent themselves well to electrification, with mass production economies of scale helping to steer the market. The light commercial vehicle sector has been slower to adapt to electrified powertrains, but with low and ultra-low emission zones arriving in cities the world over, LCVs are now firmly in the spotlight when it comes to meeting clean air targets.

The past two years have seen a boom in the electrified one-ton and two-ton light commercial markets, and the Transit Custom PHEV is a plug-in version of Ford's revered 54-year-old nameplate. Unlike rivals such as LDV's E80 and the triumvirate of incoming electric vans from Groupe PSA that are targeting 200 and 300km (125 and 186-mile) ranges, Ford has prioritized maximum usability for its plug-in commercial. The first PHEV in the segment, the plug-in Transit can travel much longer distances due to its 1.0-liter Ecoboost petrol engine which extends its total range to 499km (310 miles) by charging the on-board battery pack when longer trips are required. Electric-only range is 56km (35 miles) and charging time is 2.7 hours on a 7kW Type 2 AC point, 4.3 hours on a 240V connection. Four selectable driving modes control the available

VITAL STATISTICS

Motor: 1 x 92.9kW

Battery: 13.6kWh Li-ion

Range: 56km (35 miles) EV-only/
499km (310 miles) total

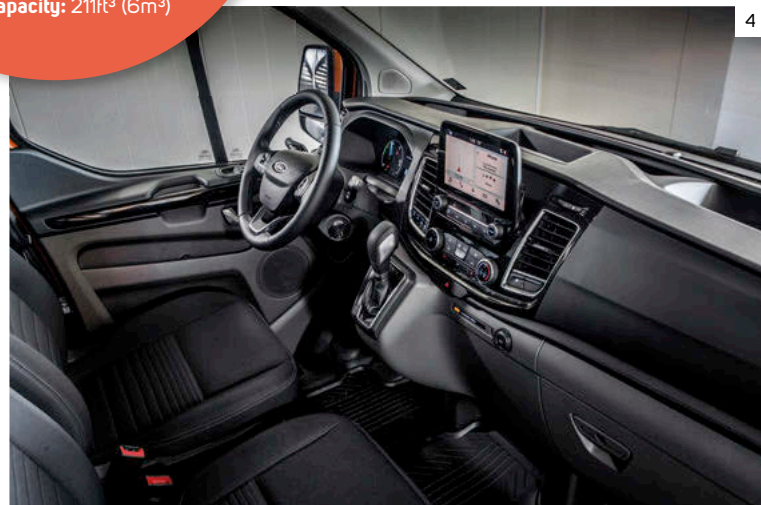
Engine: 999cc turbocharged petrol

CO2 emissions: 60g/km (NEDC)

Max speed: 120km/h (74mph)

Payload: 2,491lbs (1,130kg)

Load capacity: 211ft³ (6m³)



4

The project could not have been achieved to such short timescales any other way."

Precise packaging

One key challenge was the packaging of the electric powertrain. Ford was keen to offer its customers no compromise to the internal combustion-engined Transit Custom's 211ft³ (6m³) load volume. Facilitated by careful packaging of the compact battery pack beneath the floor, the 13.6kWh capacity of the lithium-ion unit is correct for current market demands, concludes Ian Porter, chief Transit Custom program engineer at Ford of Europe. "Battery capacity has been specifically tuned to balance the electric range, weight, and recharge times. Based on the London trial and other data we believe the electric range is sufficient to meet the urban usage requirements."

An unnamed supplier provides the liquid-cooled battery which is mated to a 92.9kW (126ps) permanent magnet three-phase AC synchronous traction motor, the rating of which Porter declares was a result of the year-long London tests. "The fleet trial vehicles had a smaller e-motor than the final production solution. Data and feedback captured during the trial helped to confirm the requirement for a larger e-motor."

Primary development started with the removal of the engine and gearbox from a diesel Transit, replaced by a three-cylinder petrol engine and permanent magnet three-phase AC synchronous generator. The electric drivetrain, batteries and charging system were then added. "Everything was squeezed into whatever space was left from taking the diesel engine out



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5. A London trial using Transit Custom PHEVs revealed 75% of 150,000 miles used electric power

6. James McGeachie, engineering director at Prodrive Advanced Technology, helped develop the electric vehicle

7. As well as the plug-in hybrid, a fully-electric Transit Custom is expected

and whatever space we could find in the chassis under the load bay. We were working with very small clearances, and essentially we tripled the complexity of the drivetrain," reports McGeachie.

Another challenge was taking Ford's EcoBoost three-cylinder engine and mating it to the generator. "That had never been done before," McGeachie says. "A key technical barrier was the design of the coupling between those two devices. We spent a lot of time testing the coupling to ensure it would be a robust solution."

Testing, testing

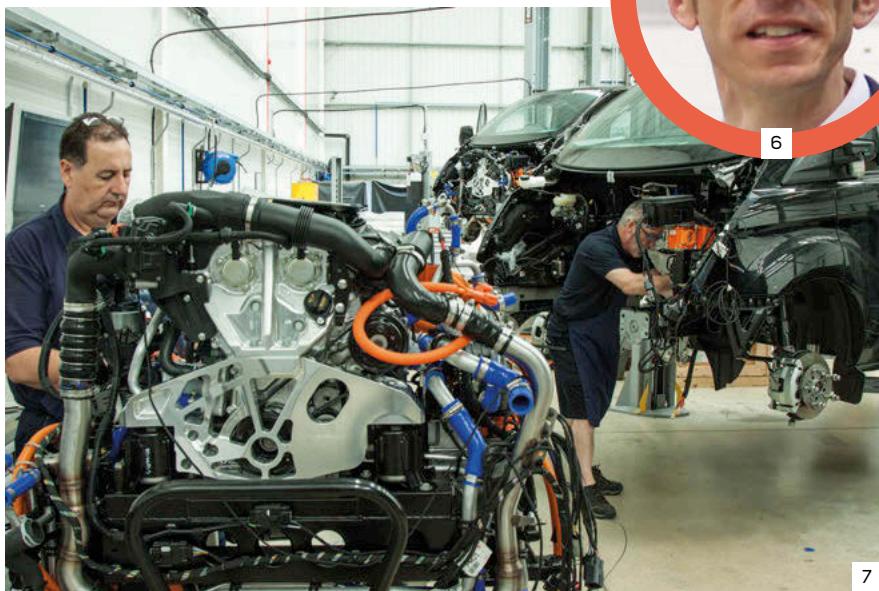
"We delivered the 20-vehicle fleet for London trials, so they had to be robust, but they also had to go through Ford's production vehicle test routine. It goes to show the level of engineering these vehicles had to satisfy. Ford also took them winter testing and the first two vehicles were driven from Dunton to Sweden. Nothing was spared just because they were prototypes."

The feedback from the 150,000-mile London trial was overwhelmingly positive. It revealed that 75% of the fleet's mileage in Central London was completed using electric power alone, dipping to 49% in Greater London. The first time Ford had given such early prototypes to customers, valuable feedback was directly incorporated into the production vehicle development program, which was led by Ford with support from its supplier partners. Fully connected, the Transit Custom PHEV will offer geofencing capability from spring 2020, which can automatically switch to EV mode when entering a low emission zone or a user-specified area.

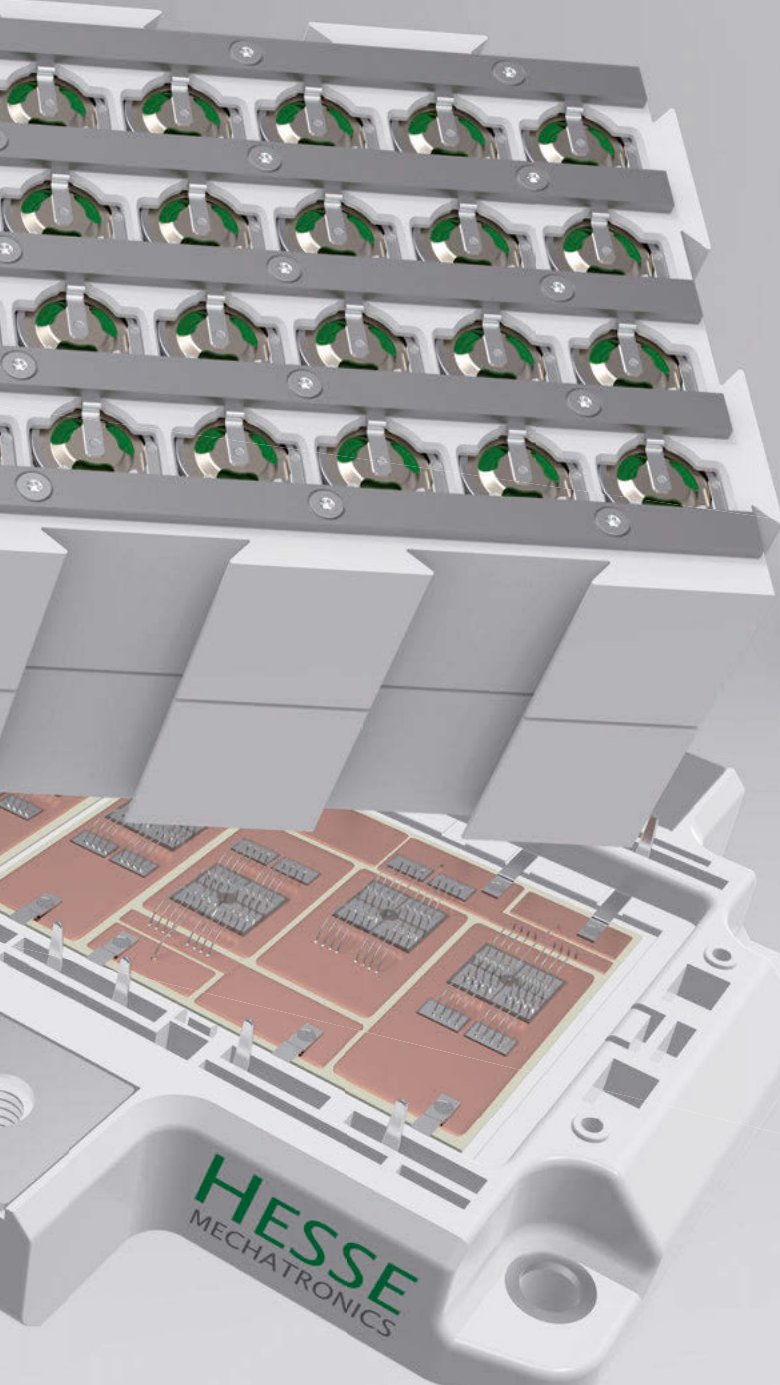
Alongside the plug-in van, an eight-seat Tourneo Custom PHEV shares the same powertrain, and 48V mild-hybrid technology has found its way into new EcoBlue Diesel Hybrid versions of the Transit Custom and two-ton Transit. A fully-electric Transit Custom is also under development, mooted for a 2021 launch. For now, though, with the electrified commercial market still to reach maturity, the Transit Custom PHEV is the right offering says Porter. "Our customers want electrified vehicles, but we understand they may have concerns about infrastructure and range. Transit Custom PHEV offers no-compromise productivity and the capability to drive on zero-emission electric power, with freedom to make longer journeys." 



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RANGE

Despite using a much smaller lithium-ion battery of just 9kW, it is able to cover 150km (93 miles) on a mixed cycle, however it has the ability to reuse 80% of the energy captured from regenerative braking to double urban range to 300km (186 miles)

CHARGING

The battery can be recharged to 80% in one hour when using a conventional domestic wall socket

Speed racer

LIGHTWEIGHT

Built from a carbon fiber frame and composite body panels, the bike weighs just 150kg (330lbs), which is almost 25% lighter than typical electric sports bikes

Electric motorbikes are becoming a booming business. To showcase where they could be heading is the Nawa Racer, a concept e-bike with a world first hybrid battery system using ultracapacitor technology

Putting a futuristic twist on the retro café-racer motorcycle, the Nawa Racer concept from French energy storage company Nawa Technologies is a mouth-watering example of how advanced electric drivetrain technology could power e-bikes and beyond in the coming years. Using a world first hybrid battery system it combines revolutionary ultracapacitors with lithium-ion to offer next-generation levels of battery

performance with ten-times more power and five-times more energy than existing tech. It is the first time an electric motorbike has used ultracapacitors and makes it possible to use a much smaller and lighter battery unit, which is ideal when mounting on the limited space two-wheeled mobility offers. Thanks to the high power characteristics of the ultracapacitors, the bike will deliver its full acceleration performance no matter what charge level is available.

To match the advanced powertrain technology is a striking modern chassis design created by UK-based engineering company Envisage Group, which uses a lightweight body built from carbon fiber and composite panels complete with classic detailing. Despite the Nawa Racer only being a vision of an electric motorbike of the future, the hybrid battery system can be applied to all forms of electric vehicle and has the potential to go into production soon. ■

FULL SCALE

The hybrid battery system is fully scaleable and can be applied to any EV, including cars

BATTERY

Located in Nawa Racer's top tank area is an arrangement of Nawa Technologies' own ultracapacitors, known as NawaCap. Offering 0.1 kWh it boosts a lithium-ion battery mounted low in the chassis where an internal combustion engine would usually be located

PERFORMANCE

The hub-less rim motor produces 100PS, delivering acceleration from 0 to 100km/h (0-62mph) in under three seconds, and a top speed in excess of 160km/h (100mph)

DESIGN

Inspired by 1960s café racer style motorbikes, the Envisage Group design blends modern and retro with details such as LED lighting, anodized matte black suspension, and camel-colored nubuck leather

EFFICIENCY

Ultracapacitors offer ten-times more power and five-time more energy than typically available tech, and enable to reduce the size of the lithium-ion battery by half, reduce charging times and extend range by double



Future moves

With a fully-electric powertrain, inductive charging and a solid-state battery, the Lexus LF-30 concept showcases how far the brand is looking towards the future of electrification technology

WORDS: GUY BIRD





Lexus has been at the forefront of electrification since 2005 when it introduced a hybrid powertrain to its 400h SUV. It has, however, taken until 2019, for the company to finally announce plans for a fully-electric model, the UX300e, as part of its Lexus Electrified global strategy. Yet, before this announcement, it revealed its vision of the fully electric future when it took the wraps off a concept vehicle, the LF-30, featuring what possibilities of technology, performance and design can bring to its next-generation of vehicles.

At 5,090mm long, 1,995mm wide and 1,600mm high the sci-fi-looking LF-30's proportions are akin to the current Lexus LS limousine but the concept's project leader and Toyota Lexus ED2 Europe studio director, Ian Cartabiano, explains how with its longer 3,200mm wheelbase, the LF-30 provides similar levels of cabin space to the bigger LM, the luxury-appointed Lexus based on the Toyota Alphard minivan sold in China.

With its dramatically LED-lit, but closed-off interpretation of the brand's existing 'spindle-shaped' grille, wedge-shaped proportions and dramatic surfacing – concave and curvy upfront and angular and sharp towards the rear – the



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1. The LF-30 features inductive charging technology
2. By 2025 Lexus aims to have electrified versions of its entire fleet, with sales outpacing its ICE variants
3. The UX300e is the first fully-electric Lexus
4. The cockpit uses augmented reality controls
5. Seats are able to mold to passengers for comfort

concept is a major departure from anything in the existing line-up. "Management gave us a license to dream a little on this project," Cartabiano says with clear pleasure, but it is nonetheless based on mid-term technological advances that are already in the pipeline.

Notably, designers seized upon the packaging and space opportunities afforded by in-wheel electric motors on all four wheels and a more compact solid-state battery powertrain, which is stated on the concept's side sills to subtly reinforce the point. With these underpinnings and positioning, there was more potential for designers to create greater interior space than would be possible if motors were placed elsewhere and the battery pack was still a larger lithium-ion one, as the benefit of solid-state batteries is their ability to pack more power into a smaller space due to better heat resistance. In order to differentiate further, the LF-30 also proposes that its big wheels and their in-wheel motors will be able to affect body control by individual adjustment at each wheel – something Lexus is rather mysteriously calling 'advanced posture control' – through to a steer-by-wire steering wheel (which can also fold forward and out of the way in autonomous mode) plus inductive charging.

Solid plans

While hard-nosed millimeter-by-millimeter calculations on the potential space savings of solid-state batteries rather than lithium-ion batteries were not factored into the concept car's actual dimensions, "aesthetics were the only governing factor," Cartabiano concedes. Lexus's

parent company Toyota is nonetheless very much involved in the development of solid-state batteries for the future. Indeed, Toyota's senior management have indicated that a vehicle using them could be rolled out as early as the 2020 Tokyo Olympics, but probably within a one-off version of the e-Palette autonomous people mover (first shown at the 2018 Consumer Electronics Show), rather than as the start of actual production.

Koji Sato, Lexus executive vice president echoed these sentiments at the 2019 Tokyo Motor Show, suggesting solid-state was a promising technology but not quite ready yet. "Solid-state batteries can be packaged smaller," he says, "but might not be ready before the next LS," which given the mk5 version of the flagship Lexus launched in 2017 and should have at least a six-year lifecycle, would suggest that such tech is unlikely to be feasible until 2025 or later but still good for a 499km (310-mile) range or more.

As to whether Lexus might go down the 'twin-limo' route of Mercedes in offering both its next regular S-Class with probably partial hybrid as well as a separate full-electric large limousine that should closely resemble the 2019 Vision EQS concept, Sato does not explicitly reveal. However, he indicates that Lexus might choose a different top-of-the-range path, perhaps understandable given its smaller

overall range of vehicles (and sales compared to Mercedes). "Our brand icon is the LS, but the market is changing with greater SUV demand so we have to adapt," he continues. "Maybe one electric SUV flagship and one hybrid LS saloon flagship could be a solution. Don't forget that 'petrohead, car guys' tend to dominate luxury car purchases. Meanwhile, I believe the key driver for a carmaker is [to create] the dream for the customer, that's why the LF-30 concept is further afield than the EV that is coming sooner."

The first fully-electric Lexus to which Sato refers is the UX300e. Launched in November 2019 at the Guangzhou International Automobile Exhibition, is an EV version of the compact Lexus UX crossover with a more conventional 54kWh lithium-ion battery onboard for around 400km (250 miles) of pure electric driving. Its introduction, which is scheduled for a 2020 release in China and 2021 in the UK, and the LF-30 concept suggest that Lexus and Toyota are finally embracing full EVs after decades of staying hybrid-only. 

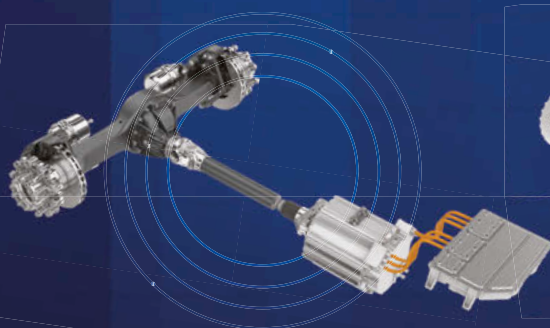


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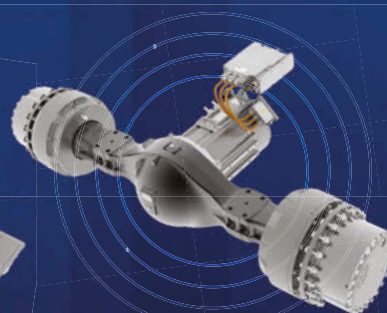
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ELECTRIC POWERTRAINS ON TEST

Our thoughts on cars we've tested recently, all of which feature some sort of advanced powertrain electrification

BMW X5 XDRIVE 45E

BMW launched its first PHEV X5 back in 2015, and now with the brand on the fourth generation of its eDrive technology the new 45e has taken the benefits of plug-in power to the next level.

Looking at the numbers and fuel economy figures it's hard to believe we're talking about a 2.5-ton SUV with a 3.0-liter in-line six cylinder engine. With an extremely generous 24kWh battery on-board powering an 83kW electric motor, it can travel on pure electric power for over 80km (50 miles) and has a claimed combined economy of up to 235mpg (WLTP). Staggering. Of course, these figures and aren't fully representative of the whole picture, but to even go near that for a car this size is a feat of engineering.

The amount of electric only driving range didn't exceed 50 miles for us but we had more than enough to suffice most of our daily driving, urban driving and school runs without needing a drop of fuel. To squeeze as much economy as possible the X5 employs BMW's intelligent energy management, which previews your route when using the sat nav and cleverly works out the optimum powertrain option of electric, hybrid or gas, and automatically switch as you drive. In Hybrid Eco Pro mode, the car will also tap into navigation and sensor data to change braking regeneration levels. We achieved some decent gains over short distances using this and the system all worked discreetly. We particularly liked the physical throttle threshold that lets you feel how much pressure you can put on the accelerator pedal before the engine kicks in, which is something a lot of hybrids lack.

The X5 45e really does open the door wide open for anyone considering the move to electrification but worried about giving up their 'big' car. It offers the best of all worlds. The one drawback is the sacrifice of the two rear pop-up seats in the trunk to make way for the battery underneath. However, the X5 is hardly short on space.



MERCEDES EQC 400 4MATIC

Mercedes-Benz's first fully-electric vehicle is a timely one. With the premium electric SUV market rapidly growing in depth with the likes of Jaguar and Audi giving Tesla less elbow room in the market, the marque has wisely opted to electrify this segment before than anything else.

The EQC, which is part of the brand's EQ branded electrified range, is built on a majorly modified GLC platform and is equipped with an 80kWh battery powering two asynchronous motors – one on the front axle, and one on the rear. It produces a powerful 408hp and 760Nm torque. While a relatively weighty kerb weight of 2,495kg (the battery alone is 652kg) throttle response is sharp and acceleration of 0-100km/h (0-62mph) is smooth. Mercedes claims the EQC will get up to 259 miles range (WLTP). We found a full charge was a little way off this but it delivers a refreshingly accurate real world range, with remaining mileage staying true to your driving style.

Comfort is a key aspect to the EQC, something you instantly notice

inside the luxurious and tech-laden cabin. Driving-wise, the flat-bottomed architecture offers a pleasant low center of gravity, but most notable is how silent the ride is. Even for electric car standards, this has to be the most inaudible cars we've tested. We applaud the engineering on the electric powertrain for its lack of whir or whine, which can cheapen the premium experience. Inside the cabin, without the IC engine, insulation against exterior road noise is incredible.

It takes around 11 hours to fully charge from wallbox, or just 40 minutes for a 10-80% recharge via high powered charging thanks to its 110kW DC on-board charger. Customers will receive a one-year subscription to the Ionity network, which is a nice perk, but they won't be able to take full advantage of the highest capacity charging.

For a first try, the EQC is very impressive. With over US\$10bn behind the development and deployment of EVs and 10 new models on the way over the next year, there was little doubt that it would disappoint.



LEXUS UX 250H

With Lexus leading the charge in hybrid technology since the mid-1990s this fourth generation hybrid system employed in the UX comes with much expectation. Sharp styling and a distinctly plush Lexus cabin appealingly packages this self-charging hybrid crossover SUV, where a 2.0-liter four-cylinder Atkins Cycle petrol engine is coupled with a nickel metal-hydride battery and electric motor on the front axle (or both for its E-Four version).

What makes Lexus' self-charging hybrid different to others is that it can engage its store of electric power and be driven over short distances and low speed using battery power alone. This comes in useful when

in crawling traffic and the engine quickly comes to life at around 8-10mph, however trying to keep it in EV mode for as long as possible proved to be a fun game.

The driving dynamics of the UX offers a light, comfortable and easy to drive affair that's well-suited to city driving. Thanks to the electric power, acceleration is given a bit of a boost with a 0-100km/h time of 8.5 seconds, making it just nippy enough to zip through gaps in city traffic. Economy figures claim 49.5-53.2mpg, and our test car was hitting the high 40s after a week of motorway and short hops around town. The UX is quiet, comfortable, and even has a CVT gearbox that we haven't moaned about yet.



BMW 330E

With an updated battery the 3-series hybrid gets even more appealing for mid-distance commuters and company car owners.

BMW has introduced a bigger battery with new technology for a more energy dense pack that's boosts capacity from 9.2kWh to 12kWh to accompany the 2.0-liter four-cylinder petrol engine. The result offers a claimed economy of 148mpg, with 35 miles of that being able to be driven using pure electric. In our real-world tests we were seeing figures of around 35mpg and pure EV driving in the mid-20s. This increase in battery power has made the new 330e more viable as an option for short commutes without ever filling up with fuel, and the battery can be fully recharged in four hours using a 3.7kW supply. The plug-in power combination offers 249bhp and 420Nm of torque for a satisfying push of acceleration. Getting to 0-100km/h in 5.9 seconds is no slouch, however even being a shade lighter than the previous hybrid, we were aware of the weight of the battery and the engine having to lug it around when it's drained. 



↓
PROFILE: JAMES MCGEACHIE

Job title: Engineering director

Company: Prodrive

What was your career path up to now?

After completing an electrical engineering degree at Nottingham University, I started at British Steel in 1995. I spent three years there. It was a massive operation and as an engineer you got to see and do everything. I then spent 10 years with a small engineering consultancy, which placed engineering resource into OEMs. I was working in the vehicle security division at JLR, tasked with delivering the very best anti-theft measures for the X-Type. I joined Prodrive in 2008 working on a whole variety of projects. It was technical, and I really enjoyed writing control strategies, designing electrical architectures and installing harnesses. After six months I took on the role of chief engineer, electrical, then three years later I became head of electrical systems, to finally engineering director with the responsibility for all engineering delivery.

What are the best and worst parts of the job?

It's the mix I really like, both in terms of what I do and the variety of projects. I might be customer facing and responsible for strategic

planning, but I'm still hands on. Another plus is that we do see the results of our projects very quickly, sometimes in a matter of just a few weeks. There can be huge pressure, which goes hand-in-hand with the short timeframes that we specialize in. But when you deliver, the feeling is fantastic. A great example was the PHEV Transit that we developed with Ford. To turn around 27 fully-functioning, road-ready vehicles that were ready to be trialed by members of the public in just 20 months was a huge task, but when you look at what we achieved, it was pretty amazing.

What inspires, excites and worries you most about the electric vehicle industry?

The automotive industry doesn't have many moments like this where it's not natural evolution. Right now, we're where the industry was right at the start – wondering about all the different types of propulsion. To be an engineer right now is incredibly exciting and I think we won't have a watershed moment like this for another 50 years. There's so much going on and nobody truly knows what technology might be around the corner.



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To be an engineer right now is incredibly exciting and I think we won't have a watershed moment like this for another 50 years

What is the greatest challenge for the industry to overcome for the mass adoption of EVs?

Many people are genuinely sceptical about EVs, with most concerns relating to range. I think it's only when we start to see 'real-world' ranges of circa 300-400 miles that drivers will start to consider an EV. Of course, cost is another factor and there's no denying that EVs are more expensive than ICE counterparts. In terms of making them more affordable in the short term, the only options are the manufacturers taking a hit or increased government subsidies to encourage drivers to make the switch to electric.

What are you working on at the moment?

Broadly speaking, electrification and actuation-type systems are taking up a lot of our time. What we're really seeing is our aerospace work increasing, with the transfer of technology from what we've developed for the automotive sector. Automotive is going

through a revolution, overtaking aerospace in terms of pioneering electrification technology.

What has been the biggest technology breakthrough for EVs in recent years?

The obvious answer is batteries. Ever since we produced our first hybrid with GM in 2001, there's always been limitations with range. Evolving battery technology has counteracted this and encouraged the ongoing development of EVs as viable, usable alternatives to ICE-powered vehicles.

Which OEM(s) do you think are doing great things with electrification technology?

Tesla really got things moving and you can't forget about Toyota and its hybrid work. Nissan deserves credit for being the biggest seller and you have to acknowledge the huge investment that BMW made in the i3 and i8. Currently though, it's Volkswagen and its I.D. range that is looking the most intriguing. With

Volkswagen you know that when they do something, they do it big, and there's a lot riding on its success following the fallout from the Dieselgate scandal.

What is the Holy Grail for vehicle propulsion – what would you like to see powering the typical car in 2030?

The sensible solution is electric in the short term. I think 2030 is probably a little too soon for fuel cell technology. The Holy Grail will be something with a high range and why over-complicate it with alternative means of power. If such a range isn't feasible across all EVs, then that's when you get into the more off-the-wall alternatives. I think the availability of smaller, more affordable, energy-dense batteries will be key to making it happen. For commercial vehicles, however, I still think hybrid represents a great solution while we're waiting for suitable EV technology that can be applied to trucks.

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Roger Atkins



► The last decade has been a missed opportunity for UK electrification. In fact, it can be traced back to 2007, when the Rt Hon David Cameron opened a state-of-the-art electric vehicle factory in Binley near Coventry - The Modec Factory. A BEV proposition targeted at the urban operating, defined mileage, back to base commercial vehicle market. A 5.5-ton GVW load shifter that immediately caught the eye of major UK supermarket chain Tesco for its home delivery grocery service, UPS and FedEx for package and parcel deliveries, Speedy Hire for plant delivery, and a smattering of local authorities in and around London. Hats off to all of them for swallowing the brave pill back in the day. Among several challenges, including a lack of sales, minimal funding, and zero government support, Modec fell foul of the banking crisis of 2008 and finally got unplugged in the spring of 2011. A similar fate awaited Smith's - another UK EV player, amazingly in the business of electric vehicles for almost a century.

Meanwhile, tailpipe emissions from diesel taxis, buses, and delivery vans progressively triggered a public health crisis with airborne particulates, and whilst whistleblowers such as Simon Birkett who founded Clean Air London in 2010, took the authorities to task over the issue, it was a can to kick down the road for most politicians and the press. And then, in 2015 it all changed. Public awareness of tailpipe pollution rocketed as fast as VW's share price plummeted, and diesel quickly became a dirty word. Having invested heavily in diesel technology OEM's had to quickly reboot and rethink a way forward. It needn't have unfolded like this to my mind, if only we had truly focused on the twin imperatives of both CO₂ reduction and urban air quality improvement by the mass adoption of electric commercial vehicles

// We are witnessing a seismic shift in the right direction //

The Modec BEV created a buzz back in 2007 but a number of challenges saw the company collapse



© TrevorPower at English Wikipedia

such as taxis, buses, and vans. I wouldn't be surprised if the pareto principle wasn't at play in that regard where 80% of the pollution was caused by 20% of the vehicles. Public policy, whilst well intended, hasn't helped much along the way.

With a solo occupant driving minimal daily miles, why discount a personal EV car from the public purse when a taxi or shared vehicle picks up 10 to 20 people per day driving anything up to 200 miles? Electric buses are an even better bet of course.

I've always believed the best match for mass adoption of EVs was never going to be the private car, and whilst the decade past has been a missed opportunity, we are now witnessing a seismic shift, in my view, in the right direction. Amazon is investing heavily in Rivian and ordering

100,000 delivery vans, Hyundai is putting £100m into truck company Arrival in the UK, and electric taxis are beginning to hook up wirelessly to an ever greener grid system. Who knows, maybe one day London and other cities around the globe might emulate Shenzhen in China where the current EV bus fleet boasts 20,000 vehicles and a similar number of electric taxis. ◻

Roger Atkins has been a leading voice in the auto industry for the past 30 years, with the last 15 spent as specialist on EVs. He is the founder of Electric Vehicle Outlook, as well as an author, consultant and brand ambassador to a number of leading companies in the automotive sector

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Greg Offer

► Cost – it is one of the ultimate factors influencing the buying decision of an electric vehicle. Questions over range anxiety and charging infrastructure are still important but are frankly secondary as pre-order figures show there are already more than enough people who want to buy an electric car.

For example, over 400,000 people put a deposit down on a Tesla Model 3 without even sitting in one. There has probably never been a model launch in the history of the automotive industry with this much excitement and demand. The only thing holding the rest of us back from buying a car now is quite simply cost. Like the majority of prospective new EV owners, I'm just waiting another year or two for a bit more choice, and for the prices to drop down a little, and then along with millions of others I will be making the switch.

The key to making this happen faster is battery technology. Previously the automotive industry has been focused on the energy density of the lithium ion batteries, as this was necessary to develop vehicles with enough range. Cell manufacturers have worked hard and have focused on squeezing as much energy in as possible. Some of the compromises when increasing energy are well understood – you can't have both high power and

energy, and some of the new materials such as silicon in the anode and high nickel cathodes can increase degradation and shorten lifetime. The compromises can be acceptable if you understand the trade-offs. However, some of the unintended consequences are not as well understood. In a recent Elon Musk interview, he talked about how dangerous it is for engineers to fall into the sub-system optimization trap. I recently came to the conclusion that the battery industry has fallen into this trap for their cells, at the expense of the battery pack.

“Most lithium-ion cells are significantly sub-optimized for thermal management”

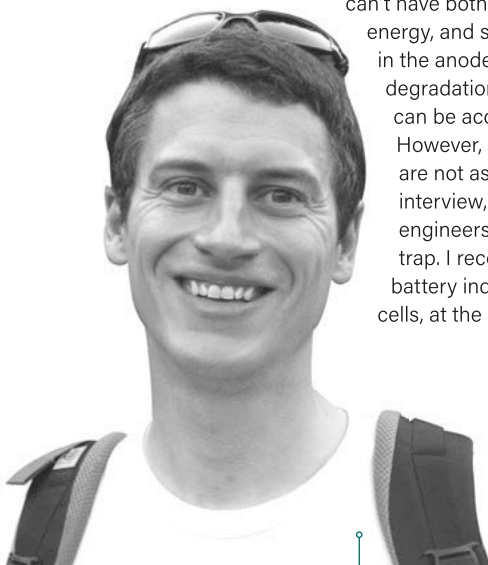
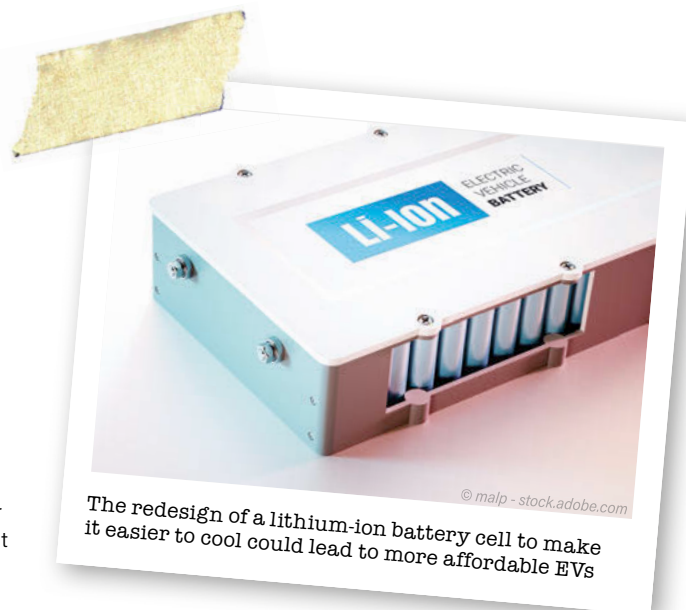
The redesign of a lithium-ion battery cell to make it easier to cool could lead to more affordable EVs

The latest research in our group supports this hypothesis, as we have demonstrated that most lithium-ion cells are significantly sub-optimized for thermal management. Essentially, they are very difficult to keep cool, and the only way to prevent them overheating compromises their performance and increases degradation. We believe this has happened because there is no easy way to compare how easy it is to cool one cell compared to another. Instead, the industry has competed on energy density, minimizing any material that is not contributing energy.

Our models show that by redesigning a cell to be easier to cool would decrease cell energy density by a few percent, but could increase energy density at the system level by up to 20%. This could either increase range or reduce cost.

In response, we have proposed a new metric – the cell cooling coefficient – which is an empirically measured standard. Comparison drives competition, hence if adopted, manufacturers will begin to compete to design better cells. In the same way, pack designers will have a metric to pick the best cells, enabling them to design better battery packs. The end result of cheaper electric vehicles will benefit everyone. □

Dr Gregory Offer is a Reader in mechanical engineering at Imperial College London. His research focuses on battery, fuel cell and supercapacitor technologies, mainly in transport



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Wheel POWER



Electric in-wheel motor technology first appeared over a century ago, but with major pushes in emission-free as well as autonomous mobility, could it be about to revolutionize the electrified transportation market?

WORDS: **RICHARD GOODING**

The dawn of a modern all-electric mobility era has brought with it many benefits, aside from the obvious environmental advantages. And as the automotive industry embarks on an increased take-up of zero-emission vehicles, there are still new technological avenues to explore. As long ago as 1900, the Lohner-Porsche Electric Voiturette System pioneered by Ferdinand Porsche featured internal-pole motors on the front hubs, but decades after the technology disappeared, the elevated prominence of electrified powertrains has signified a re-evaluation of the in-wheel concept for the automotive and light commercial sectors.

The headline advantages of in-wheel motors over transmission-based electric powertrains are additional levels of interior space as well as drivetrain (battery to wheel) efficiencies of up to 98% – compared to the 30% of an

"We plan to be selling these [motors] in volumes of up to millions by 2023-2025"

Chris Hilton, chief technology officer, Protean Electric



internal combustion vehicle – easily controllable high levels of torque, as well as independent wheel control. Leaders in the in-wheel field include Elaphe Propulsion Technologies and Protean Electric, and both have been investigating the benefits of the technology since the early 2000s.

"Our motor design was iterated through applications and OEM, Tier 1 and user requirements," states Gorazd Gotovac, chief technical officer at Slovenian-based Elaphe. "We've spent 15 years perfecting the design to be as compact as possible, manufacturable in series, durable, and cost-effective. Our motor is more of a top hat over the hub with a friction brake, using existing mass-produced suspension, knuckles, hub bearings and brake systems. It's highly scalable and customizable." At 1,500Nm, the company's L1500 in-wheel

1. In-wheel motors integrate power electronics, digital control and brakes

2. Elaphe's design is scalable and customizable

motor is the most torque-dense on the market, each unit making 108kW (147ps). Optimized for low-volume production, the L1500, like others, is compatible with all drive layouts.

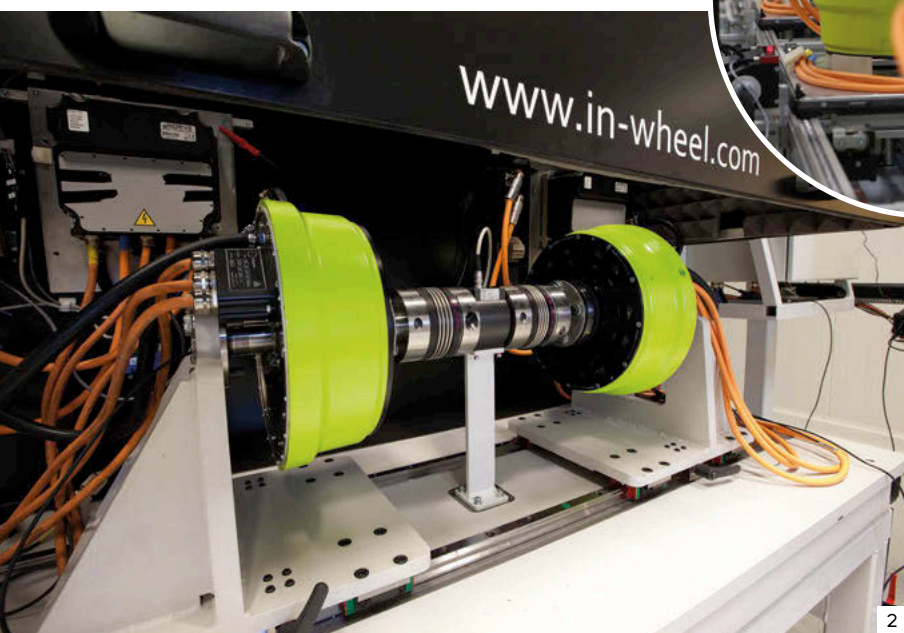
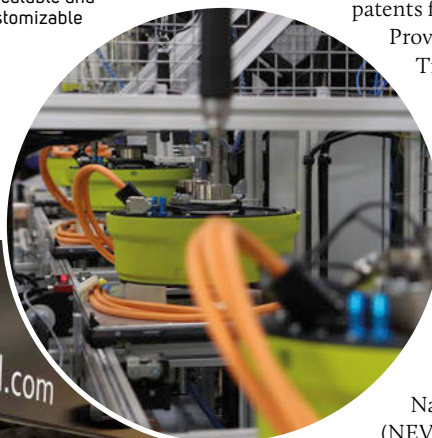
That same versatility is shared by Protean's ProteanDrive technology. Under development by the UK-based company for over a decade with over 160 patents filed, it is now in its fourth generation.

Proving a mass-production process at its Tianjin manufacturing base in China, its first major vehicle program is reported to start in 2020. "We've had interest from customers who have an existing two-wheel drive electric platform and want to make a four-wheel drive version, but they can't package a second electric axle," explains Chris Hilton, chief technology officer at Protean Electric.

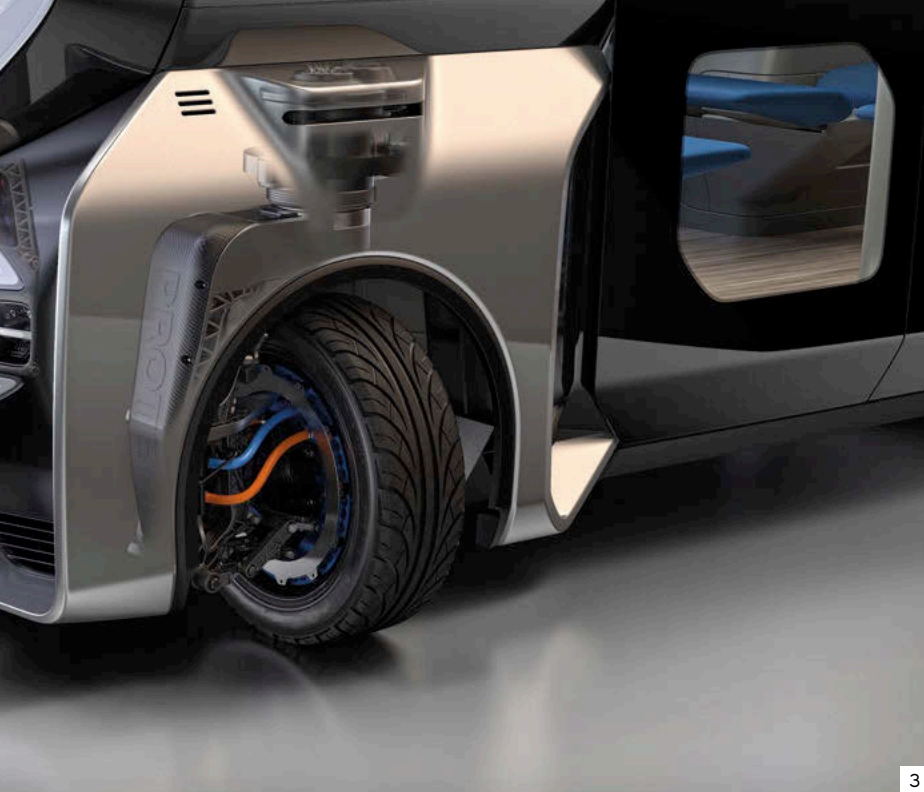
But the company, now owned by National Electric Vehicle Sweden (NEVS), has also pioneered the Protean360+ 'corner module' concept. For use in next-generation urban mobility pods, it offers a limitless 360-degree cornering capability and integrates powertrain – including an 80kW (109ps), 1,250Nm ProteanDrive Pdr8 permanent-magnet synchronous motor – steering and suspension components into a single module. A critical target was to allow vehicles to 'kneel' for stepless kerb-to-vehicle access. It's this enhanced maneuverability which has attracted potential customers, says Hilton.

An almost infinite steering capability means the vehicle can just spin around and around, and all four wheels can do it independently. Fitting the same unit to all corners of the vehicle also helps slash costs.

Although autonomous pods make up one burgeoning area of the in-wheel market (the global intelligent mobility



2



In-wheel motors are about as good as it gets because they are almost entirely independent of the vehicle body. A vehicle can have different dimensions as it doesn't make much difference to the powertrain." Also favoring modularity is Israeli startup REE, which debuted its in-wheel modular platform at the 2019 IAA Frankfurt Motor Show, alongside its Japanese Tier 1 strategic partner Musashi Seimitsu.

More traditional passenger-carrying vehicles have already accepted in-wheel technology with open arms. Electrically-powered buses are becoming common in cities, and Ziehl-Abegg's ZA wheel electric axle drive module has enjoyed success, due to the compact design advantages in-wheel motors bring. "You can design the vehicle according to the mileage needs of routes," explains Dr Sascha Klett, technical managing director at Ziehl-Abegg. "This means you can define the size of the batteries and alter charging strategies," he states. There are other parallels with solutions designed for smaller vehicles, one being

3

sector is forecast to be worth over \$1tn per year by 2025) they are not the sole beneficiaries.

Universal benefits

"Connected Autonomous Shared and Electric (CASE) vehicles are getting the most of the media attention," remarks Gotovac. "But the benefits of in-wheel propulsion are universal and will find their way into more traditional vehicles. Every vehicle can benefit from lower weight and energy consumption, extra interior space, and improved maneuverability," he adds.

However, the autonomous sector is one which will be best served by in-wheel solutions. "Autonomous vehicle developers benefit greatly from the increased safety and data-related benefits of a distributed in-wheel powertrain. The speed and accuracy of control brings benefit to all levels of vehicle autonomy. Additional modularity also has a large effect on the way these vehicles are designed. The freedom of design and flexible modular platforms are key to user-focused mobility," Gotovac believes.

When it comes to modularity, Hilton concurs. "The Holy Grail is to get vehicle design as modular as possible.

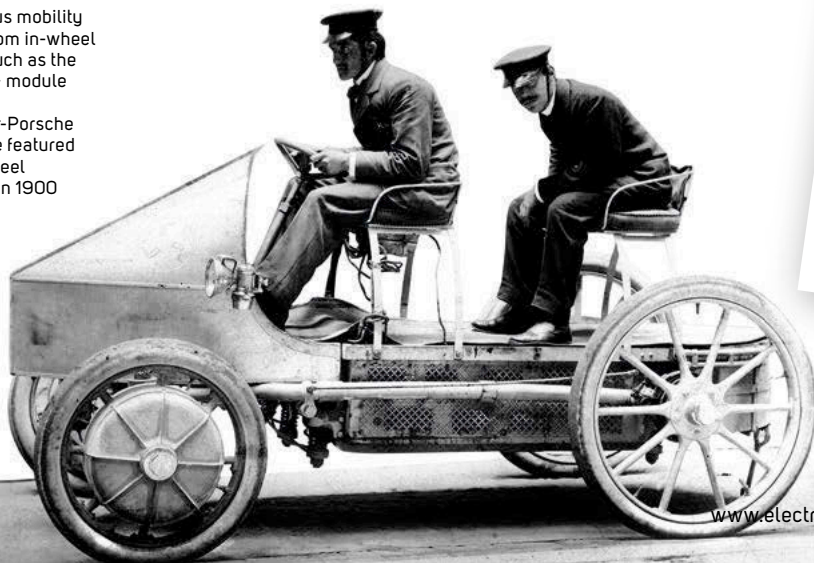
ELECTRIC DREAMS

While Porsche is known for creating some of the finest and most famous big-engined sports cars ever, it could have been a totally different story for the manufacturer as its first ever vehicle was actually electric. Ferdinand Porsche had a penchant for electric power and started his career designing electric power drive systems, including the Egger-Lohner C.2 Phaeton in 1898, which was powered by an octagonal electric motor and had a top speed of 25km/h (15mph). In 1900, he created the motorized wheel hub, with the innovation featured on the Lohner-Porsche Electromobile. It had a chassis and body made of

wood with one internal-pole motor on each of the front-wheel hubs, with an output per motor 2.5ps and a maximum speed of 37km/h (23mph). It was powered by a forty-four cell 80V lead battery and could offer around three hours of use at top speed. It was a revolution at the time, however the technology failed to take off as it was too heavy with the car weighing two tons, it also lacked power and range, and there was insufficient infrastructure.

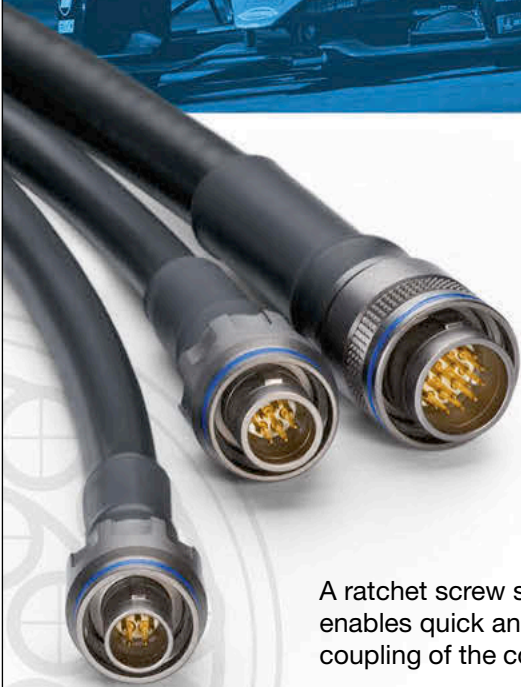
3. Autonomous mobility will benefit from in-wheel technology such as the Protean360+ module

4. The Lohner-Porsche Electromobile featured electric in-wheel motorization in 1900



4

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in-wheel systems' ability to be integrated into hybrid and fuel cell applications.

Hilton confirms in-wheel technology lends itself well for those demanding hybridization. "It's a good system for the hybridization of an existing platform because it's relatively undistruptive," Gotovac agrees. "Hybrid applications benefit more in terms of time-to-market, due to major packaging issues that OEMs are experiencing with hybridization of in-production vehicles." Because the technology fits around mass production parts, retro-fitting to IC vehicles is also appealing. "Our in-wheel technology integrates with other components, so it fits with existing platforms and future vehicles designed more around the user than powertrain," he states.

Increased unsprung mass generated as a result of the in-hub motor weight was a potential challenge in the past, but it has now been solved. "Most OEMs see this as a completely manageable task," states Gotovac. "We did work in the early days with Lotus to establish what you would do to mitigate the effects," says Hilton. "Essentially, you end up stiffening the suspension to cope and the impact is very small." According to Klett, the answer is also similar for larger-sized vehicles. "You can optimize the suspension so there's no critical situation," he reports.

Readiness and risk

When it comes to the mainstream adoption of in-wheel solutions, the long-standing question of market maturity remains. With OEMs such as Lexus reported to be considering in-hub



5



"Over the next few years we will see a mix of fuel systems, but we will see more requests for electric buses"

Dr Sacha Klett, technical managing director, Ziehl-Abegg

5. Ziehl-Abegg's ZAwheel is a single in-wheel electric hub drive for commercial vehicles

6. Buses benefit from noiseless and 100% emission-free driving

technology, could it finally be on the brink of a market breakthrough? Japanese supplier Nidec announced its first in-hub system in 2019 with mass production expected to begin in 2023. Hilton explains that market readiness and risk have been key drivers until now.

"With all disruptive technology you develop it to the extent that the market will take it at a time. It would have been pointless for us to have been producing hundreds of thousands of these five years ago because there was no one ready to take them. The technology develops alongside the customer willingness to adopt it. However mature it is, until the technology's been adopted by somebody and it's run millions of miles on the road, the customer will always consider it as a risk compared to traditional drive systems.

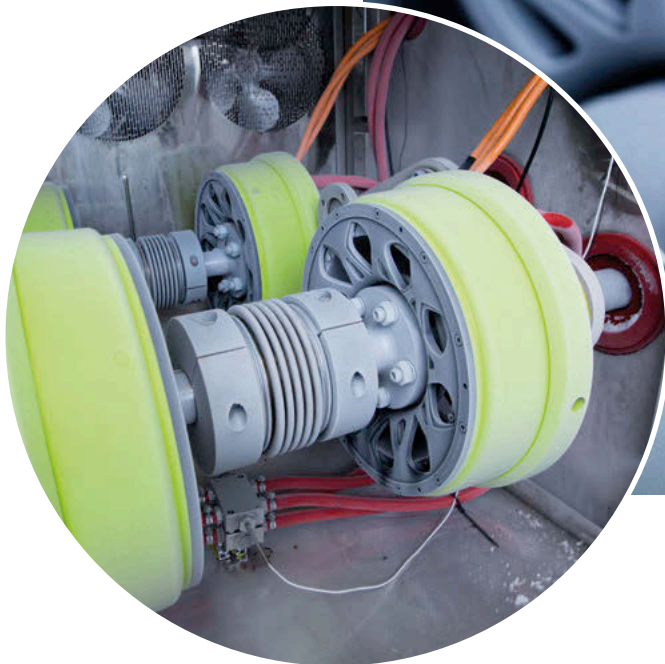
"We have a product that I would describe as mature. It's been through comprehensive testing to prove its durability and design, and our main push is to get it to high volume



6



7



production. We plan to be selling these [motors] in volumes of hundreds of thousands getting up to millions by 2023-2025. That's an ambitious target but we can see the opportunity," he enthuses.

The increased visibility of all-electric, hybrid and hydrogen fuel cell vehicles over the past 10 years has accelerated the development of in-hub technology to create that opportunity. "It's been very helpful," acknowledges Hilton. "We could look at predictions of the growth of the electric vehicle market and it was always about to take off. It didn't really happen until Tesla became successful. Since then, interest in the whole sector has grown and that benefits us."

Gotovac agrees. "This just shows a positive trend. It was expected that the market from IC would evolve through hybrid, plug-in hybrid, central motor BEV, e-axle BEV to multiple-wheel hub drive. Now everyone is under pressure to find the next key technology and not be caught by surprise again. This makes in-wheel technology a serious topic."

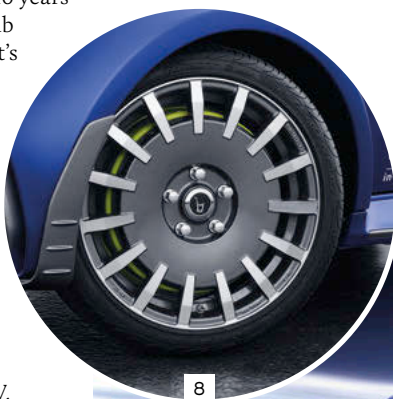
Klett also believes that the next five years will be crucial for commercial and city transportation systems. "RATP in Paris has announced it wants to have 80% of its buses powered electrically by 2025. There is a clear will around Europe and all over the world to go for this. Over the next few years we will see a mix of fuel systems, but we will see more

7. Testing of in-wheel motors involves climate chambers with extreme low temperatures and shock testing

8. The Akka Bertone Smart project is based on an F1-inspired Smart car with electric hub motors that produce 283ps

requests for electric buses because passengers like the feeling of driving electrically, and I believe they will say they it's more comfortable," he states.

A similar timescale to Hilton and Klett's is also seen by Gotovac. "We anticipate a non-negligible share of in-wheel powertrain vehicles by 2025, but it is hard to define what will be mainstream. Like other technologies, in-wheel motors will likely grow through niches that will see the benefits emerge relatively soon, and then spread through most segments. Many OEMs will still use central e-motors for a decade or more, but vehicles will be more diversified than ever in this upcoming era of mobility." 



8





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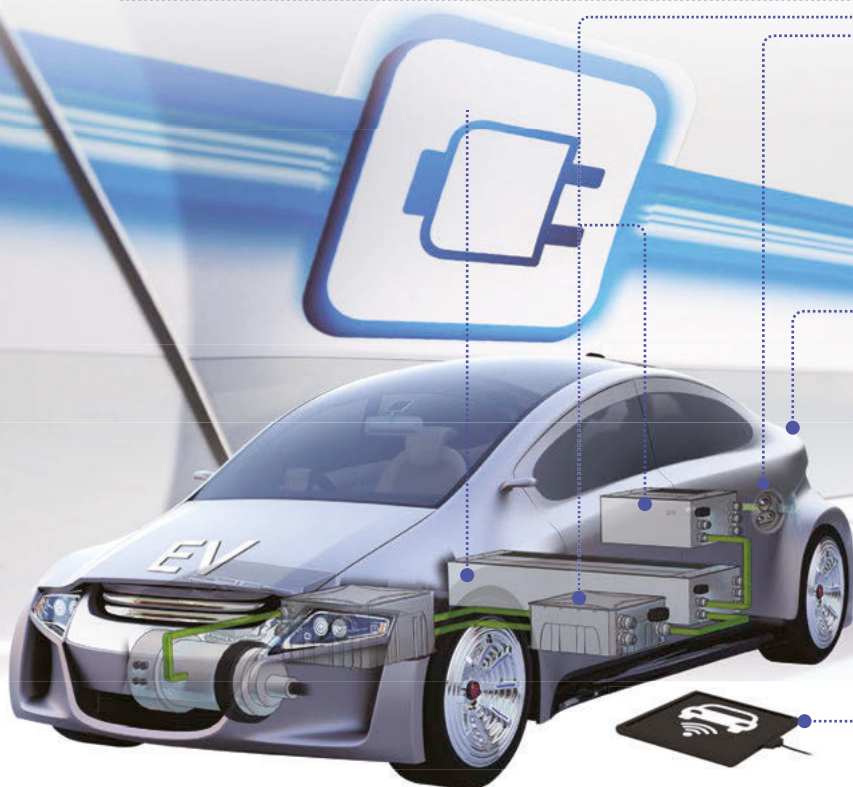
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ISSUE

High-profile coverage of lithium-ion battery fires is generating cautious policies around handling and use – but are the risks being overplayed?

WORDS: ALEX GRANT



From smartphones to jet planes, supercars to static storage, lithium-ion batteries have become the default for diverse industries and a driver of technological change. Global production has risen quickly, from 20GWh in 2010 to 120GWh in 2017 according to a recent European Commission report, and it's underpinning the shift to electric vehicles. Almost half of that capacity – and growing – is going into 'mobility solutions'.

However, that proliferation has been accompanied by high-profile safety concerns.

Battery fires have grounded plane fleets, caused expensive recalls of consumer electronics and led to hold luggage restrictions for flights. But while a burning electric car still piques the interest of content-hungry news agencies, the risks appear to be overstated.

Statistics are skewed by the smaller vehicle parc, but the track record is good. Of the 480,000 batteries Envision-AESC has built for Nissan's electric vehicles, the company says there have been zero 'critical incidents' globally. Tesla, meanwhile, claims one fire per 273 million km (170 million miles) travelled in

its cars in 2018, 15% of which were due to external factors such as arson or nearby objects burning. The US average is one fire per 30.5 million km (19 million miles).

Paul Shearing, professor of chemical engineering at University College London and Royal Academy of Engineering chair for emerging battery technology, says it reflects well on the industry. "Some manufacturing defects can be latent for quite a long time, then mature into something more substantial, but it's important to emphasize that these are very rare. Failure rate for all lithium-ion batteries is somewhere between one in 10 million and one in 40 million cells. Not all fail spectacularly – some fail in a more passive way – but the failure rate is impressively low."

In-life abuse is harder to avoid, particularly short circuits caused by impact damage, but protective structures used by car makers appear to be effective. The National Highway Traffic Safety Administration (NHTSA)'s most recent data shows electric and hybrid cars only caught fire in 1.6% of fatal accidents in 2017. That's proportionally unchanged since 2013,



"If a manufacturer uses simple battery management systems the battery can overheat or be charged at too cold a temperature"

Professor Dr Andreas Hintennach, senior manager, battery research, Daimler AG

despite the number of crashes doubling as the parc increased. Gasoline and flex-fuel vehicles caught fire in 3.4-3.5% of incidents respectively.

The materials used aren't necessarily more volatile. NHTSA research into battery fires showed that liquid diethyl and dimethyl carbonate electrolytes used in today's lithium-ion batteries have a similar flashpoint to fossil fuels, dispersing as heavier-than-air vapors and localizing fires beneath the vehicle. The Agency said flame-retardant alternatives, such as fluorinated and organophosphorus additives could further reduce the risks.

1. Envision-AESC has built over 480,000 batteries for Nissan's EVs, with reports of no critical incidents globally

2. The Porsche Taycan employs an 800V architecture to enable it to charge at rates of up to 350kW without the risk of overheating



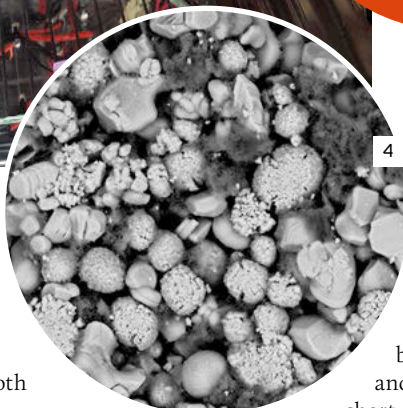


The hard cell

But these incidents do come with unique challenges, as Paul Freedland, principal engineer at Cosworth, points out: “The big problem is that as the lithium-ion cells start to burn, they provide both the fuel source and the oxygen to sustain combustion, which makes them very difficult to extinguish, and keep extinguished. The fires also normally started due to internal faults within the cells that can be very difficult to detect prior to the onset of thermal runaway.”

Consumer expectations are also putting additional stresses on batteries. New models are offering longer ranges, higher performance and exponentially faster charging speeds. At 350kW, the Porsche Taycan is charging more than 100 times faster than a domestic socket, the typical method 10 years ago. This high-voltage charging requires careful management to avoid damaging the cells.

“Lithium-ion batteries work through what we call a ‘rocking-chair mechanism,’” explains Billy Wu, senior lecturer at the Dyson School of Design Engineering at Imperial College. “During charging, lithium ions move from the cathode to the anode, which is normally made of graphite. These materials are layered like sheets of paper, and if you try to force too many lithium ions in at once and they can’t move into the material fast enough, that leads



“If you try to force too many lithium ions in at once and they can’t move into the material fast enough, that leads to lithium dendrite forming”

Billy Wu, senior lecturer, Dyson School of Design Engineering at Imperial College



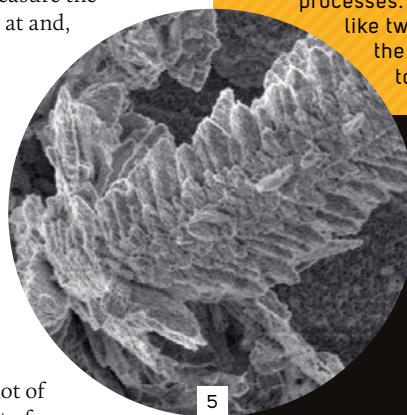
to lithium dendrite [shards of metallic lithium] forming.

“If that touches between the anode and cathode it causes a short circuit, like if you put a spanner across a lead acid

battery. When that happens, lots of current flows and lots of heat is generated, which leads to this feedback loop of thermal runaway, and the battery catches fire,” explains Wu.

“What you should do is measure the temperature you’re charging at and, if it’s very low, you gradually ramp it up. You can also do pulse charging where, instead of constantly applying current, you periodically give the battery time to rest.”

Professor Dr Andreas Hintennach, senior manager, battery research at Daimler AG, also sees effective management as a vital component. “We pay a lot of attention to the development of our battery management systems, and we program them in a way that [dendrite formation] is very unlikely to happen,” he says.



SAFETY IN SOLID STATE?

Solid-state lithium-ion cells appear to be the most likely enabler of a generational leap for electric vehicle batteries, promising much higher-energy density than liquid-electrolyte units and hopes for faster charging, too. But its inherent stability also offers safety benefits, which could re-shape pack design.

“Solid-state solutions aren’t production ready yet but do offer the ability to eliminate internal short-circuiting from dendrite growth and a non-flammable interface between the current collectors,” says Giles Muddell, chief engineer of control systems at Prodrive. “If they can be shown to meet the energy density, power density, cost and cycle life required of automotive batteries, this would represent a significant step in safety.”

Imperial College’s Wu also sees big potential for the technology, including removing the need for complex thermal management systems, but he believes consumer electronics will get it first. “I think it’s more than 10 years away. When we create a new chemistry it drops into the existing manufacturing systems that we have, whereas when we manufacture solid-state batteries we’ve got to change a lot of equipment and processes. Engineering solutions, like tweaking how you cool the battery, are a lot faster to implement.”

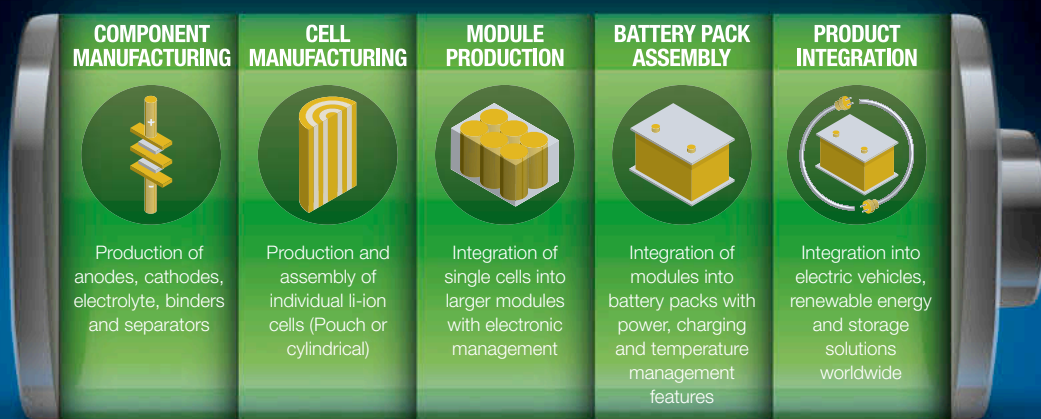
3. Cell testing is a vital element to battery development and design

4. Battery electrodes as seen under microscope

5. Battery management systems are necessary to prevent dendrite formation occurring

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"If a manufacturer uses simple battery management systems that do not pay attention to that, the battery can either overheat or be charged at too cold a temperature. If the battery management system is programmed in the wrong way, or is too simple, it will not meet European standard and it can happen during regular charging. This has nothing to do with the material itself – it's related to how the cell is manufactured, and if the battery management system is intelligent enough."

Keeping cool

Cell temperature can also be difficult to control with faster charging speeds. According to Gael Chouchelamane, chief engineer, battery systems at Ricardo, ultra-fast charging (UFC) generates 15-18kW of heat, compared to 3-4kW under normal driving conditions. In turn, this makes air-cooling inadequate, so manufacturers are introducing more sophisticated measures to keep the maximum cell temperature under 50-55°C (122-131°F) during peak operation. Above this temperature, the electrolytes can vent as a gas, and the cell itself can break down. This is becoming harder to manage. "Approximately 5% of the pack cost is

represented by the battery thermal system," says Chouchelamane. "This is likely to increase in the future with new requirements such as ultra-fast charging. Improved performance of cold plate using ethylene glycol is mandatory but has limits, and it is likely therefore that thermal engineers will increasingly opt for direct immersion cooling of the cells.

"Once the heat has been extracted from the battery pack, it needs to be dissipated to the ambient air. To achieve this, the air-conditioning system will be under high demand during UFC and will require upsizing of the evaporator cooling the fluid that cools the battery, in parallel with uprating of the air-conditioning compressor, condenser and cooling fan.

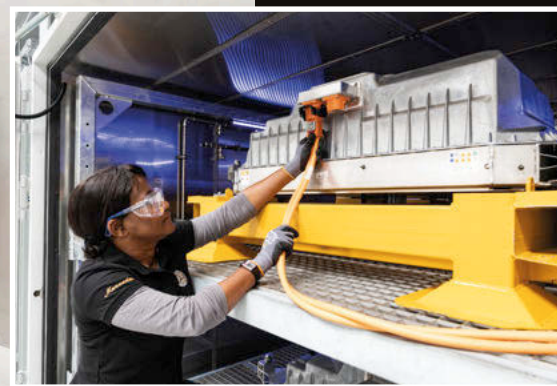


"Approximately 5% of the pack cost is represented by the battery thermal system. This is likely to increase in the future"

Gael Chouchelamane, chief engineer, battery systems, Ricardo



6. The Mercedes fully-electric EQC underwent extensive battery testing, including cold chamber testing to examine how cells react to extreme temperatures





7

Unfortunately, these measures will lead to additional cost as well as increased NVH."

Research at Cosworth, meanwhile, showed that fast charging reduces both lifespan and energy retention, and that these problems are compounded by inadequate cooling. Temperatures above 80°C (176°F) can cause physical damage to the microporous separators between the electrodes, as well as the active materials, Freedman says. New separator materials, designed to melt and close the pores to interrupt the flow of ions, could help shut down the battery before thermal runaway begins.

Better design

The bigger challenge is corner cases, according to Giles Muddell, chief engineer of control systems at Prodrive. The rise of more advanced manufacturing processes are delivering more consistent cell performance, he says, but it's not possible to monitor every cell individually.

"For example, it is difficult to predict all the cell temperatures when a car, after being driven in arctic conditions and with ice packed around part of the battery, gets plugged into a fast charger. Such a failure to predict cell temperatures can result in a cell overheat situation," he says.

7. The coolant line and cell monitoring unit contributes to keeping Mercedes' battery system at optimal temperatures

8. Cell analysis provides engineers insight into how to maximize battery performance and manufacturing methods

9. Ioniq's high power charging network has also had to solve thermal management challenges

"However, as the EV design community becomes more and more familiar with such problems, we are able to specify design rules that either design the problems out of a pack, and/or place sensors in the correct positions to be able to detect the onset of the problem and then mitigate it."

Hintennach agrees. "Our former battery management systems were a lot simpler than today's. They were even more restrictive, because the less you know, the more careful you have to be. The better you understand it, the better you can play with the parameters and still have the highest safety," he says. "We are handling hundreds of volts, but EVs are considered to be very safe." 



9



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Smooth operators

Times are changing for oil companies, so will the advent of e-lubricants and e-greases be their saviour?

WORDS: ROB CLYMO

Oil companies have enjoyed a boom throughout the years in which the internal combustion engine (ICE) has been king. Fuel for running vehicles and oil for keeping the moving parts working efficiently have been very good for business. A lucrative line in aftermarket products has been an additional benefit for oil companies.

But times are changing and diversification seems like the logical way forward, which is why the oil industry is increasingly turning towards the electric and hybrid marketplace to help prop up demand for conventional oil-based products. The result is a growing range of new e-lubricants, dedicated to the smooth running of EVs while at the same time trying to ease the friction over profits.

Global players such as Shell and ExxonMobil have been quick to move, even if it's hard to see how they can expect to enjoy the same returns that the ICE has provided them with for such a long time. These companies have to innovate, and in the growing EV market there is now demand for thermal fluids used for e-motor cooling, along with the direct cooling of e-motor windings, inverter cooling and battery thermal management. Electric engines also require supplementary e-motor bearing lubrication, not to mention more conventional greases for wheels and steering.

In that respect the signs are good for companies such as Lubrizol and Afton Chemical, petroleum additive suppliers whose main customers are the oil companies and OEMs. Adam Banks, e-mobility marketing manager, from Afton Chemical believes the company is set to benefit from the fact that it is one of only four additive companies in the world, yet he adds that the cost of developing new products places the lubricant industry second only to the pharmaceutical industry.

"It's an evolution rather than a revolution," says Banks. "The development time cycle for a transmission means decisions are being made now for, say, launches for 2021/2022, which is maybe when we start to see a tipping point in sales for hybrid and electric vehicles.

"For hybrids, the transmission is where the electrical and mechanical power combine," he adds. "One of the big challenges is heat, which we need to make sure we're managing properly and protecting the lubricants so that they don't degrade over time.

"Another characteristic of the lubricant we need to get right is the protection of materials



"Next-generation electrified designs will bring a more challenging environment for the lubricant"

Xavier Branquet, global lead, OEM Group, Lubrizol





2

1. Lubricants protect the inner materials and components of an e-motor, such as copper used for windings

2. Electrification is presenting engine oil and lubricant companies with new challenges as well as opportunities

like copper or precious metals – things that you see in sensors and in the windings of the motor as well. That's always been a requirement to some extent, but it's even more important now."

This new generation of lubricants have to be even more versatile than before. "It has to do all the things a traditional lubricant had to do – very sophisticated things that have been developed and honed for 50 years," Banks says. "Now we're adding on a whole lot more requirements as well. We've got to get the friction in the clutches right, we've got to protect gears, got to stop rust, and stop foam."

The increasingly sophisticated e-axle is another key area. "That's where you consolidate the differential, the power electronics, the electric motor and the control system into one compact, modular unit," says Banks. "That makes it very easy for people to outsource or to have modular systems, and that means everything is all tightly packed in together."

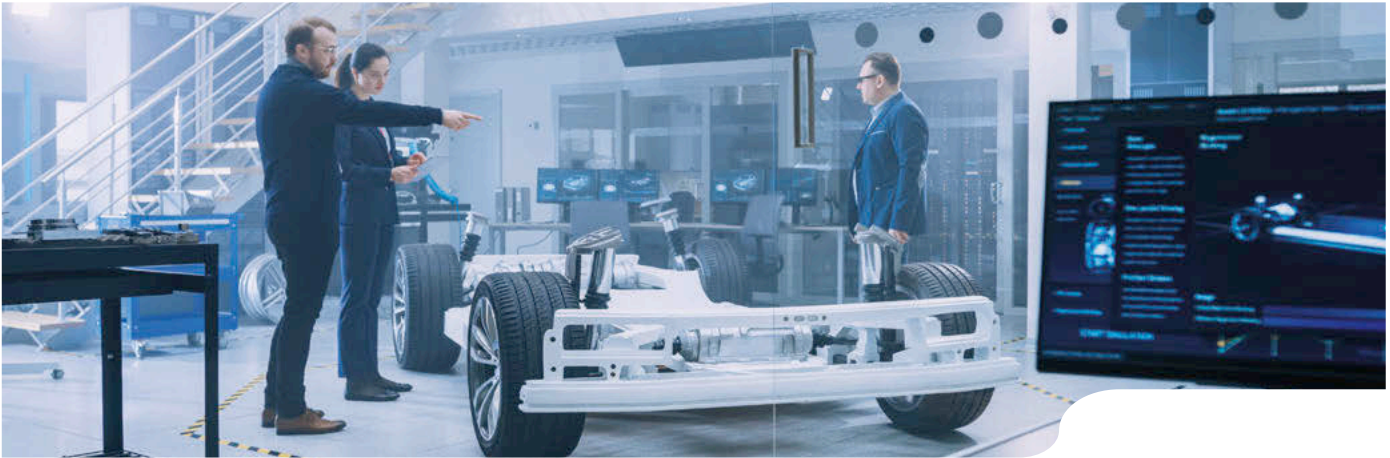
As a result, it will often be part of a one-fill scenario. "There are different ways of doing it," says Banks. "Some companies will have a glycol system with an air gap to cool the electric motor and oil to lubricate the gears. The

Nissan Leaf is an example of that. The next step on from that is lubricating all of it with an oil. Oil isn't as good as glycol at transferring heat, but you can apply oil directly to the electric motor. It actually works out to be more efficient, but applying oil directly onto a very hot electric motor is a technological challenge."

There is another step on from that in the form of a multi-speed e-axle. "That's what we're expecting: two or three-speed electric transmission," says Banks. "If you can make an EV more efficient you can have a smaller battery or longer range or whatever you want. That's the other area we're developing for. Whereas the hybrid transmission lubricants are maybe more of an evolution of our existing transmission lubricants, the e-axle area is a bit more of a new development."

Fluid transition

The developments don't end there. "Actually e-lubricants or 'e-fluids' aren't the only domains we are looking at," says Xavier Branquet, global lead, OEM Group at Lubrizol. "We are looking at electrification technical challenges, which are broad and complex, from two perspectives: e-powertrain and e-powerplant, or batteries, with the two



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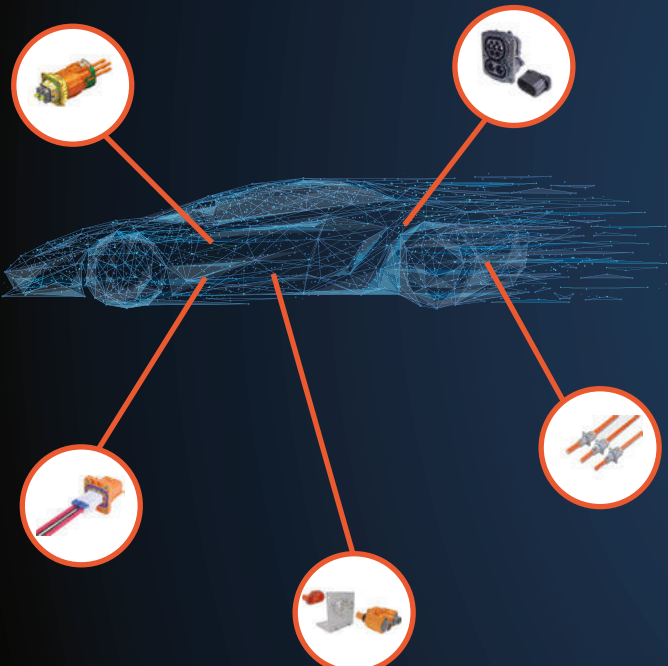
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having touch points, such as thermal management. Within e-powertrain, you'll find solutions as e-powertrain fluids, hybrid compatible engine oils and e-greases.

At e-powerplant level, battery cell chemistry is key, from binders to rheology modifiers that include electrode insulation materials. Lubrizol is working toward enhancing the performance and safety of lithium-ion batteries, which is crucial for the development of electric vehicles, as well as battery thermal management.

"We are expanding our e-mobility solutions beyond vehicles to provide solutions for the charging infrastructure, with EV charging cable jackets for high-end applications," says Branquet. "We aim to satisfy the various needs for each of the players along the value chain, including cable manufacturers, OEMs and end users."

It's also worth considering how different e-fluids are compared to their traditional counterparts. "Next-generation electrified designs will bring a more challenging environment for the lubricant: increasing

"Bearings, transmission systems and so on all need fluids that are able to operate at these high speeds"

Dr Selda Günsel, vice president of technology, Shell



voltages, different temperature regimes, more copper wiring and structural plastics," says Branquet. "Ever-tightening efficiency targets along with improved thermal conductivity drive fluids to lower viscosities where durability becomes a tougher challenge. Conventional fluids may not deliver the performance needed in the higher-stress

environments. For optimum efficiency, speed-to-market and reduced risk of failures means that developing dedicated e-fluids in parallel with the hardware is paramount."

Bigger picture

Meanwhile, Shell's vice president of technology, Dr Selda Günsel, knows exactly what the market demands, and is the lead of a global group of scientists and engineers working on the company's specialty products. "Electric vehicles operate under totally different duty cycles to those that use conventional engines," she says. "They operate at very high speeds, so bearings, transmission systems and so on all need fluids that are able to operate at these high speeds. At high speeds you can get a lot of

air into the fluid, and if you get air bubbles into a lubricating fluid you can cause severe cavitation and bearing failures, so the high-speed aspect is one issue. Also, electrical components have a lot of new materials, so we have to make sure that our fluids are compatible with those."

Günsel explains that in conventional lubricants a lot of additives are used for reducing friction or preventing wear on rubbing surfaces. These additives are actually corrosive to electrical components, so the formulations have to be changed and tailored to work in the new operating conditions and

GOING GREENER

EVs will make an enormous difference to Shell's business, according to Richard Tucker, the company's e-fluids spokesman. He explains that in years past, a lot of used oil removed from cars would simply be incinerated. The way EV motors and transmissions are produced means the new products are predominantly aimed at manufacturers, rather than the aftermarket.

"OEMs are much more discerning now," he says. "But they are also working with lead times of three or four years, and in the electric transmission space everybody is learning at the same time. These products are directed mainly at the first fill for OEMs market. That's the way the world is going for EVs. The big volume is at the moment is in engine oils, it's consumption, so you need top-ups. But modern engines have to be much more efficient because of emission, and that should see much less waste."



3

3. Shell has developed a range of e-motor oils and lubricants to cope with the high speeds they operate



4. The all-electric Formula E race series is helping to push EV development along with many of the world's biggest automotive OEMs involved, including Porsche which has ExxonMobil as one of its technical partners

MOBIL EV

Just like Shell, ExxonMobil has also been investing time and money in a new range of lubricants aimed at meeting the growing demand for EVs. Mobil EV is a suite of products that have been carefully developed to meet the tolerances in electric motors, transmissions and running gear that go to make up a battery-powered vehicle. ExxonMobil has also partnered with Porsche in Formula E racing, a series that is now well known as a proving ground for new products. Formula E is likely to see more interest from e-lubricant manufacturers as it evolves, particularly because it allows companies to try innovations before they reach the mainstream market.

with the new materials. However, rather than being created from scratch, in the case of Shell the new products are based on what has been done before.

"Shell has been doing product development of lubricants since the 1920s," says Günsel. "We have a lot of history on what works in a given application and experience in different areas; a hydraulic system is different to an engine and a electric vehicle is different again. So we have a lot of background information, we have that understanding of how molecules work between rubbing surfaces. We are using all of that history and adapting it for new operating conditions and materials."

And yet still, after years of producing products such as fuel and engine oils that effectively get burned, the need for these new e-lubricants is tiny by comparison. A lot of components in EVs are sealed units that basically need very little maintenance until they reach end of life. "That's absolutely true," Günsel agrees. "Lubricants for electric cars have sealed systems, which unfortunately for us is different to our current factory refill and aftermarket business model. We all have to change our

oil because over time it oxidizes, you get a lot of dirt particles and so on."

Product diversification and development are key, and data makes the process much more streamlined. "We've got access to big data and artificial intelligence too, so we can look at chemical composition versus fuel performance correlations," says Günsel. "And when it comes to simulations we are doing a lot of modelling work. It starts with that modelling work and physical experimentation too, but the modelling allows us to shortcut a lot of this development. This is a big trend in technology management work."

The advent of e-fluids could, perhaps, mean rather less waste oil in the future. Old oil, which has degraded through use, is a problem

that doesn't go away as quickly as the vehicles that used it. Shell maintains that it is on course to cut its carbon footprint by "around half by 2050". In response to changing needs the oil giant created its New Energies business in 2016, which currently involves the company investing between \$1bn and \$2bn a year on alternative fuel and power development and projects until 2020.

The focus is clear: new fuels and power. Shell says that new fuels will revolve around hydrogen, biofuels and electric vehicle charging. While production of all three will still put a strain on our increasingly fragile planet, the sight of oil spots on the road might one day be a thing of the past. 





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Current AFFAIRS

The roll-out of EV charging stations and charge-points is increasing steadily, but is it quickly enough and in the right places?

WORDS: FRANK MILLARD

Charging electric vehicles (EVs) seems straightforward enough, but there are potential pitfalls in the establishment of a comprehensive infrastructure. The charging network must cater for a growing number of vehicles and expanding at a similar rate to ownership as well as according to differing requirements in different places at different times. It also needs to consider the grid, which must itself increasingly depend on renewable energies. So, different solutions are likely to be applied, such as forecourt charging, local charge points, home and work (off-peak) charging, induction charge-as-you-drive, AC and fast DC charging.



1

European governments are subject to international climate agreements and have a growing awareness of environmental concerns, so are keen to make efforts to meet standards and are committed to emissions reduction. For example, the UK government announced recently that electric vehicle charge points are to be fitted in all new homes.

A Department for Transportation (DfT) spokesperson states, "We want to support the growing uptake of electric cars, and for this country to be the first place in the world where every home with an associated parking space has an electric chargepoint. Through our £1.5bn [US\$1.9bn] Road to Zero program and £400m [US\$520m] promise of funding for e-charging we are serious about the infrastructure for e-cars."

On September 10, the UK Government announced £400m funding to help develop rapid charging infrastructure points for EVs, the first £70m [US\$91m] in creating 3,000 new rapid charge points. Following the news, André ten Bloemendal, vice president, Europe, at ChargePoint, described it as a step in the right direction for the EV industry and necessary to get infrastructure in place to remove barriers to consumer adoption.

However, he adds that there should be more cross-industry collaboration to make current charging stations more accessible for drivers: "The answer to this is a fully interoperable, peer-to-peer roaming solution and charging stations that are designed with integrated contactless payments and ease of use in mind."

All this facilitates a speedier adoption of EVs, but other European countries such as Norway have gone a slightly different route,



"The answer to this is a fully interoperable, peer-to-peer roaming solution and charging stations that are designed with integrated contactless payments and ease of use in mind"

André ten Bloemendal, vice president, Europe, ChargePoint

27cm

The gap between a vehicle and the road surface that still allows for inductive charging

observes Bloemendal's colleague, Matthew Enevoldson. "Norway has a much smaller and relatively more prosperous population that is generally concentrated in a small area," he explains. "As such, they have gone the route of making ICE [internal combustion engine] vehicles more expensive through taxation, rather than offering large incentives on buying new vehicles.

"Norway has no value-added tax for EVs, which is 25% on gas and diesel vehicles. There is no registration tax on used car sales, no annual ownership tax, and no fuel tax. Road tolls are 'fully or partially' exempt, bus lanes are mostly open to EVs,

CHARGING WITHOUT CABLES

Wireless charging of PEVs is another solution. Inductive charging is an increasingly viable alternative to forecourt charge-points, especially for mass transit and in within contained urban areas. Moreover, systems can be extended to domestic vehicles and trucks on the road. For example, a company called Electreon is creating pay-as-you-go 'electric' roads.

Noam Ilan, VP business development, Electreon, explains: "The company is using DWPT [dynamic wireless power transfer] technology - inductive transmission via electromagnetic fields from the roadbed. The technology enables a shared infrastructure that significantly reduced the need to charge vehicle's battery during day/overnight and decreases the size of the battery, it can support any type of EV – buses, trucks, passengers – and is especially suitable for autonomous EVs.

"Electric Road technology is based on the concept of a high frequency air core transformer. The initial component of the air core transformer is an inductive stripe installed about 8-10cm beneath the asphalt. The secondary component is called the receiver and is connected to the vehicle's engine and battery within an air gap of about 27cm.

"The unique stripe is optimally shaped to improve efficiency and reduce radiation. The copper-only stripe reduces cost and the need for maintenance and increases reliability. The stripe is passive and comprises 1m segments. When a vehicle rides over a given segment, only the segment located directly under it is activated and transmits energy to the receiver thus saving energy and increasing safety."

The two main go-to-market segments are buses in the urban environment and trucks. It is almost impossible to electrify heavy trucks because the battery must be huge. A Tel Aviv demonstration is aimed at showcasing the former, and the next step will be to electrify the entire bus fleet of the city in collaboration with Dan, the city's leading bus operator. Another demonstration in Sweden is financed by the Swedish government as part of their road map to for electric roads for heavy trucks.

Coventry City Council in the UK is also intending to install a testbed and is currently exploring funding for the project. The council says the technology has the potential to address concerns and barriers to the uptake of electric vehicles by making it easier and quicker to charge EVs on the move or while parked up without the need to plug in cables, or to access roadside charging points: "The system also requires less obtrusive street furniture, avoiding clutter or obstructions on pavements, which can be particularly important on narrow streets such as those in many areas of Coventry."

public parking fees do not apply for EVs and there is plenty of free charging. Ultimately, the use of extensive low emission zones in large urban centers have made EVs the best option for most drivers.

"This method is obviously successful, but with a population of just 5.25 million, the losses seen to the treasury are not necessarily viable for larger countries. Although Norway is a prime example that charging capacity has a market incentive to keep up with the number of EVs on the road once adoption takes off.

"The Netherlands, while having a larger population, is also fairly small geographically. They do, however, have one of the highest densities of chargers in Europe. They have relied heavily on public-private initiatives, known as the Green-Deal approach. This has allowed the government to help facilitate private projects by removing legislative barriers and through connecting innovators together, with funding and know how. This approach has been twinned with similar legislative changes and incentive programs as in Norway and the UK.

"Both Norway and the Netherlands have applied a good mix of financial incentives and removing barriers of non-financial nature such as easy application procedures for installation, special lanes for EVs, and incentivising ridesharing, for example."

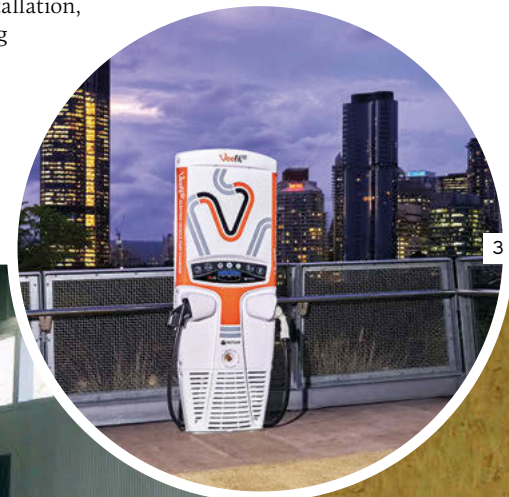
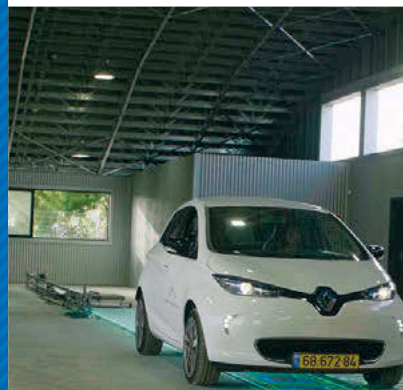
Infrastructure

Range and cost remain a disincentive to early or even medium-term adoption, which could result in a

1. Chargers are actually growing at 15-20% ahead of the market for EVs, according to ChargePoint

2. Electreon is currently testing pay-as-you-go inductive charging technology on roads

3. Fast charging is essential for EV uptake, and the number of DC rapid chargers is set to grow in the near future

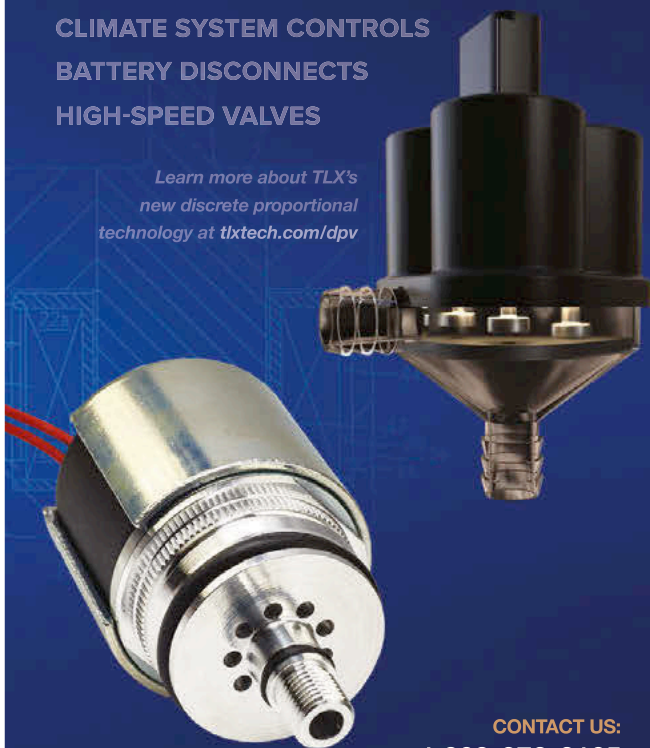


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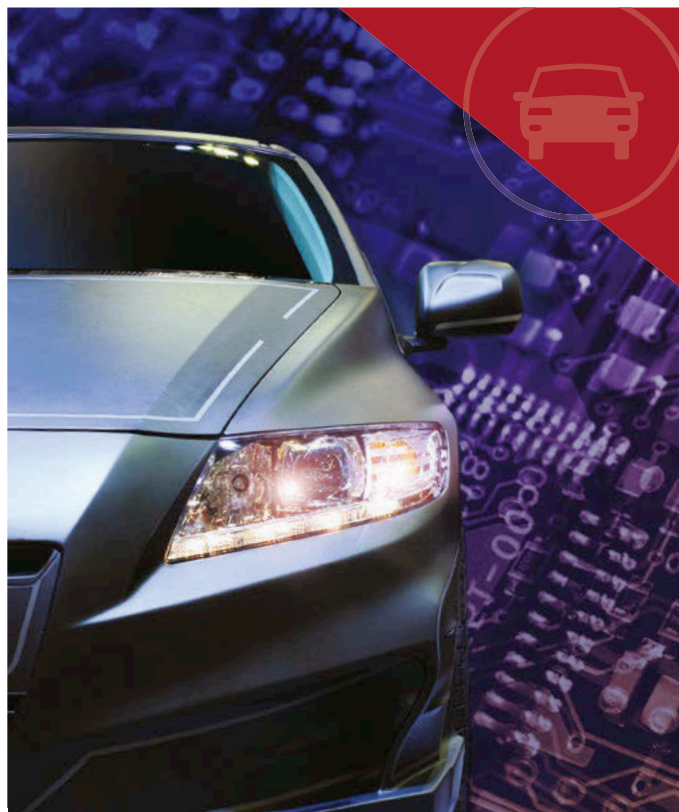
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Modeling can provide a deeper understanding of behavior and how charging types and locations will work in particular settings. ZEnMo (Zero-emission Energy & Mobility) simulations specializes in taking a neighborhood (map with physical infrastructure) and populating it with people.

"Every person and machine exhibits individual behavior – so, for example, solar panels produce sun when the sun shines, people go to work using a car – and from the collective behavior a picture emerges," says company founder, Auke Hoekstra.

"We look at driving and charging/fueling behavior of drivers to get a realistic image of fleet behavior. The difference with most other approaches is that this is very much bottom-up, with the structure being a result."

Results so far, include, he reveals: showing the Province of Brabant what a 100% renewable energy+mobility system would require in terms of trade-offs such as with investments and land use; showing people working in charging infra or EVs (members of the NKL) what to expect in terms of charging growth of EVs and charging infrastructure; supporting new tariff schemes that in turn could making charging EVs smarter so they don't overload the grid at all; and showing that most heavy trucks could be electrified [for the Rotterdam Port Authority and its customers] when they become available in a few years and how this would reduce costs.

"We simulate a neighborhood with inhabitants that fulfill their mobility needs," he adds. "We then predict who will buy an electric vehicle and when. We then model when those electric vehicles will charge based on mobility and charging needs."

Models can show in advance what subsidies and roll-out schemes are most (cost) effective, show that this is not a 'pipe dream' but inevitable and that this system will be not only more environmentally friendly but also cheaper in the end. Policy makers, entrepreneurs and buyers are slowed down by uncertainty, so it can help speed up the transition.

For the coming years, Hoekstra expects vehicles with a plug (a CCS plug in EU) to be exactly what 999 out of 1,000 cars need: "As we grow, we can learn about the proportion fast-chargers vs park chargers and about the speed car batteries will be able to handle. Maybe smart charging and V2G will make it more interesting for people to be plugged in a larger amount of time but this will mainly impact home charging and work charging. All in all I'm not worried about stranded charging assets for EVs [either PHEV or BEV]."

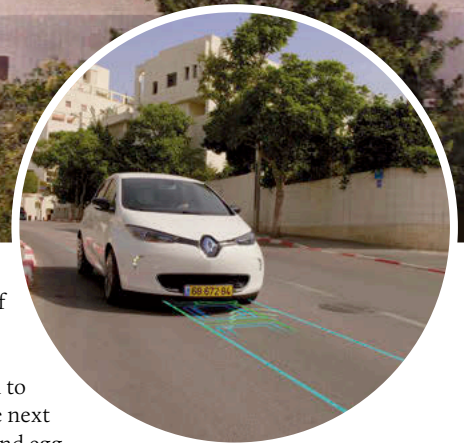
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slow roll out of the sort of charging infrastructure sufficient to feed the hungry vehicles expected to fill European roads in the next few years. This chicken and egg scenario could have an impact on both industry profits and the ability of systems to cope, no matter how integrated or 'smart' they may be.

Enevoldson is more optimistic: "While it is difficult, we should avoid thinking of EV charging as a 'chicken and egg' problem that requires thousands of chargers to be installed everywhere before EV adoption takes off. Instead, the EV industry needs to think of charging as a 'hot dog and bun' problem: as we keep adding more chargers, people will keep buying more cars and the ratio will even out over time.

"At ChargePoint we traditionally grow 15-20% ahead of market growth for EVs. That is what the market is driving. Government activity and consumer demand for EVs are the driving force behind this."

Kevin Pugh, UK and Ireland business development manager at Tritium, is of the opinion that there are many years of transition for fuel-station forecourts ahead: "The nature of evolving a fuel-heavy site from petrol and diesel into one incorporating or exclusively offering EV charging will happen only with a planned transitional model. Charging will be on the perimeter to begin with, but as volumes



4. One day it is hoped that inductive charging lanes will become commonplace on our roadways

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POP-UP STREET CHARGING

Although charging at home or at work are solutions, they are not always possible. In the UK, for example, 43% of households have no off-street parking to enable charging. A quarter of all drivers (50% in large cities) park on-street at night, so that is eight million drivers who will be looking for a convenient charging solution. In Europe, an even higher proportion of drivers live in apartments and park on-street, and there are 109 million on-street parking spaces across Europe.

As an answer, Startup Urban Electric has developed the UOne pop-up charging hub, an app-operated retractable charging solution. Designed primarily for residential streets and for public parking and charging bays, the hubs will typically be deployed as six chargers at a time in a row on one side of the street.

They offer convenience and dependability (certainty of availability of a charge point, compared to say lamp post chargers which are isolated charge points). Each pop-up charge point delivers 7kW, more than sufficient to fully charge any electric vehicle overnight, and is OCPP, so can be connected to any charging network.

The reason they are retractable is so that when not in use during the day, they do not cause street clutter or obstruct the pavement, something that both local

authorities and residents are insistent upon. Not only that, by shifting EV charging to the main off-peak period – overnight – we are helping to manage the grid, and with smart charging, no grid upgrades will be required, the carbon content of electricity is lowest at night and so is the price. It is in many ways the ideal solution and a win-win for everyone concerned. The company recently installed a prototype pop-up charging hub in Oxford, and with a further 18 demonstrator hubs agreed for installation in Dundee and Plymouth in 2020.

“Charging infrastructure is perceived as being the primary barrier to EV adoption,” says Keith Johnston, cofounder of Urban Electric. “However, the

price/lease price of EVs also has to come down to price parity with traditional ICE cars, or thereabouts, before we hit a tipping point. This is predicted to happen within the next three to five years, starting with the more expensive cars and tricking down quickly after that.

“The range of EVs probably has to increase to around 250-300 miles as well in order to go mainstream. We already have electric cars that can do this, and demand already outstrips supply for these models. We will see a surge in the number of rapid charging hubs in the coming years, and so the question of charging infrastructure is to all intents and purposes about to be solved. Now it is up to the manufacturers to accelerate the introduction of their full electric vehicles.”



change and EVs become ubiquitous, redundant fuel storage will be replaced with electric.

“The larger convenience-ready forecourts with retail and café offerings are already perfectly suited to EV charging and en-route high-power charging, as are motorway service stations,” Pugh adds. “It’s worth noting, however, that there are about 40 million vehicles on UK roads and we have some 9,000 petrol stations handling that volume, and that EV charging won’t take place only on forecourts. Home and workplace charging is ideal for daily work commuters and inner-city, low-mileage round trips. I expect this will remain the crown holder for the largest percentage of low power through-the-day/night charging. It makes sense. You plug in and forget until you have to drive again.”

Could a massive rise in EVs on the roads of Europe put an unbearable strain on the grid? Frank Muehlton, head of global business for EV Charging Infrastructure at ABB is sanguine: “If we were to reach a 100% electrified car fleet, we could expect an increase in total electricity

“It is our view that the next generation of EVs will use DC charging technology. Indeed, it is DC that is best suited to delivering faster rates of charging and we’re seeing this with the next generation of vehicles coming to market”

Adrian Keen, CEO, InstaVolt

demand of up to 10-20% depending on the country and the level of industrialization. Yet, in the short term over the next five years, given the current rates of e-mobility adoption, we should see little impact on the grid, this is even taking into consideration countries such as Norway, where over 50% of new cars are electric vehicles.”

Currently, overall predictions signal that electricity demand will grow 3,000 TWh by 2040 as a result of electric vehicles. This would see a compound annual growth rate (CAGR)



5

5. The Porsche Taycan is capable of 270kW fast charging and is slated to support 350kW via an update in the future

increase of 1.6% in today's utilities, which on a macro basis could be managed through existing planning processes.

Charging types

"Currently AC is king, but soon the percentage of 50kW DC rapid chargers will grow and we will begin to see 100kW to 175kW DC charging capability on the major networks as the norm," says Pugh. "Availability of power is an important part of the scaling up for charging capability and accessibility across the map, so combined leadership and close relationships with grid and power specialist will be the key to developing and deploying the right solutions."

Muehlton thinks DC charging is still too powerful for most consumer vehicles right now, "But all that may be about to change with the launch of the first consumer car capable of taking [over] 175kW, the Porsche Taycan."

Adrian Keen, CEO of InstaVolt, agrees, and reveals that the company spoke with car manufacturers to understand their EV roadmaps. "From these conversations, it is our view that the next generation of EVs will use DC charging technology. Indeed, it is DC that is best suited to delivering faster rates of charging and we're seeing this with the next generation of vehicles coming to market."

3,000^{TWh}

The predicted growth in global electricity demand by 2040 as a result of EVs. A CAGR increase of 1.6%

However, home and workplace charging will still be the ideal option for daily work commuters and low mileage, inner-city round trips. Enevoldson stresses that It is important not to separate out AC and DC in this discussion: "Adoption of EVs needs people to adopt a new approach to fueling their vehicle. The average car has been shown to only spend 4% of time actually driving. The rest of the time it is parked either at home or work.

"Fueling should not be seen as a singular event you do in the course of driving, but something that is done when you are not in need of transportation. Ensuring that workplace AC chargers are widely available in the UK – where 36% of commuters still travel exclusively by car – will go a long way to encouraging adoption and fighting off any worries of range anxiety." 



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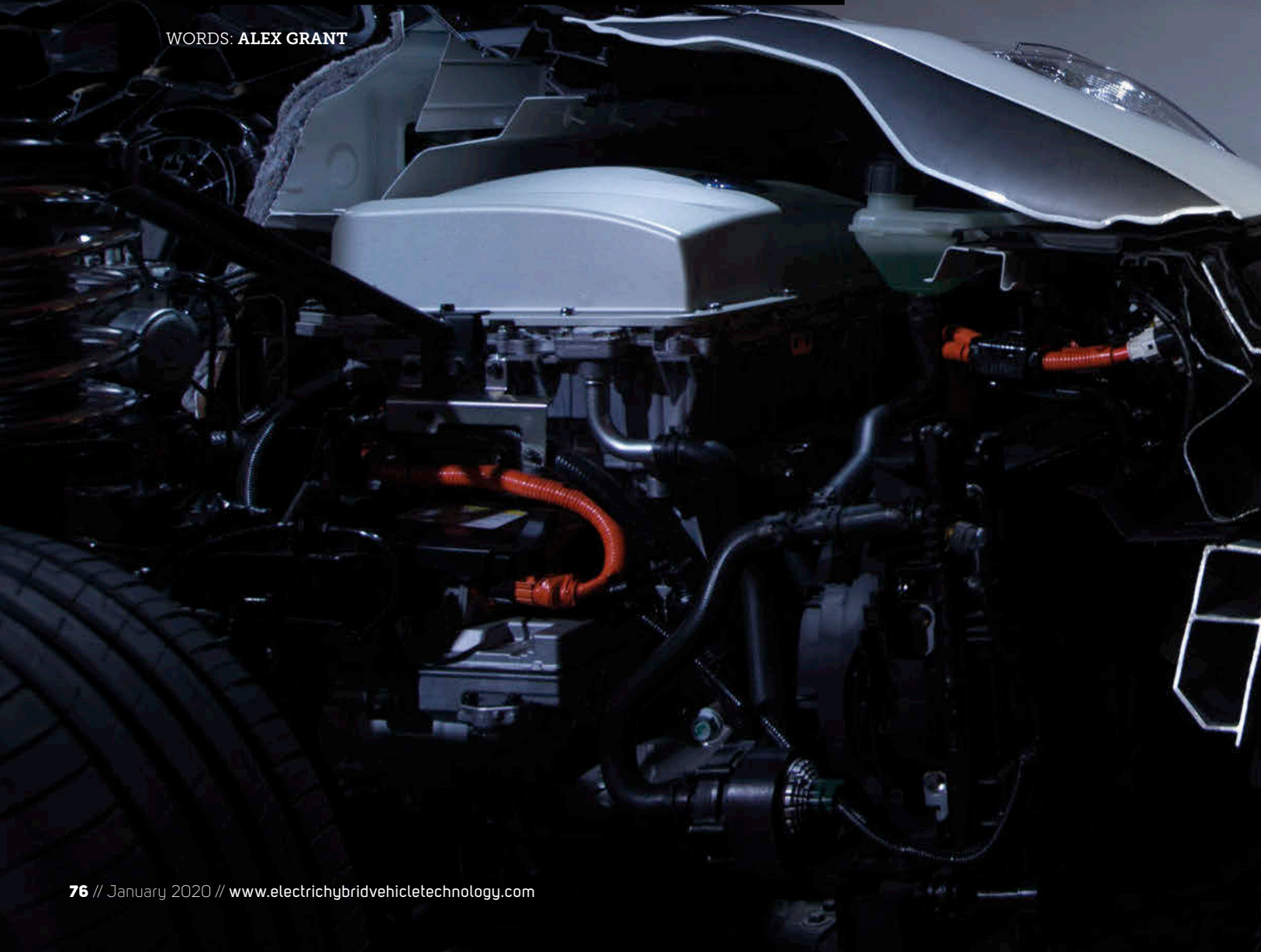
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Peak performa

Proponents of vehicle-to-grid technology claim it could be the vital ingredient for an increasingly electrified vehicle parc. But, despite the foundations falling into place, there are obstacles to overcome before it reaches mass market

WORDS: ALEX GRANT



nce





The roadmap to mass electric transport is becoming clearer, defined by tightening CO₂ limits and deadlines for combustion engines to be phased out in some of the world's largest-volume markets. It's the automotive industry's biggest step change since the dawn of mass production, but an even bigger leap for the utility companies tasked with keeping that fleet moving.

"We see an inflection point in terms of [electric vehicle] adoption around 2021," says Gregory Poilasne, chairman and CEO of San Diego-based vehicle-to-grid (V2G) platform Nuvve. "The acceleration of electric vehicle penetration is going to happen very fast and is going to drastically impact the utility space. But we are convinced that V2G is going to solve this problem of the integration of both renewable energy generation and electric vehicles."

The hardware required to enable vehicles to feed energy back into the grid isn't next-generation technology – it's already commercially available. Bidirectional charging is already supported by the Chademo standard, as is a protocol enabling the vehicle to communicate battery state of charge to the charging point and beyond. Nissan and Mitsubishi introduced this capability in production models following the 2011 Tohoku earthquake in Japan, initially to provide a backup domestic power supply during blackouts, but numerous pilots are



underway globally, examining how electric cars could mitigate their own impact on the grid.

Julian Dunn, head of energy storage products at Ricardo, sees this as a bigger benefit than providing a backup for individual homes. "Where you're really looking for V2G to make a difference is when one in three, or one in four vehicles on the street is electric. They could quite easily balance out the peak load. We're not looking at providing the base load for the country off EVs in power-cut scenarios – it's just levelling the peak load."

Research suggests this could be an effective buffer. In the UK, the National Grid mapped out the effects of smarter

"Electric vehicle penetration is going to happen very fast and is going to drastically impact the utility space"

Gregory Poilasne, chairman and CEO, Nuvve



Technologies (Cenex), explains: “By steering people away from times when the grid is congested, an indirect benefit is that you’re then moving the load towards lower carbon generation. You could maybe halve the carbon intensity if you took the energy at 3am rather than 3pm. If you’re charging at night when it’s low carbon and then you’re discharging back to the grid when it’s high carbon, then obviously you double the carbon benefit over and above smart charging.”

Tools for the job

The Chademo Association says its standard is compatible with 41% of fast-charge capable vehicles in Europe, but that share is likely to at least plateau. American, European and Korean OEMs are increasingly using the Combined Charging System (CCS), and this doesn’t have the required communication protocol built in.

charging in its 2019 Future Energy Scenarios report. This suggested that 35 million EVs would be required by 2050 to meet the government’s net zero carbon emissions target. Unmanaged, these would single-handedly increase peak demand by up to 24GW. Controlling demand using smart charging (V1G) could halve that peak to 12GW, while V2G would bring it down a further 85%, to 1.8GW.

In turn, V2G could mitigate costly infrastructure improvements. A recent Lawrence Berkeley National Laboratory study that examined California’s projected electricity requirements in 2025, showed that V1G could offer a grid-stabilising equivalent to a US\$1.5m investment in static energy storage. By comparison, V2G offers equivalent to a US\$15.4bn capacity increase.

There are other benefits too, as Chris Rimmer, infrastructure strategy lead at the UK’s Centre of Excellence for Low Carbon

“V2G using an AC system requires inexpensive adaptation of the charging terminals, and also reduces infrastructure roll-out costs”

Yasmine Assef, energy new business director, Groupe Renault



1. Nissan enables its vehicles to communicate battery state to the charge point – and beyond
2. The technology is being used in pilots to examine how electric cars could mitigate their own impact on the grid
3. Bidirectional charging is already supported by the Chademo standard
4. Nissan is also testing V2G technology at its European R&D hub

The incoming ISO 15118 standard, designed to enable ‘plug-and-charge’ operation similar to a Tesla Supercharger, will enable this, but not until the mid-2020s.

Bidirectional AC charging is also already possible, although the architecture is different. This requires the AC/DC converter – required to put DC power back into an AC grid – to be integrated into the vehicle, rather than the charging point as in a DC system. “Groupe Renault has V2G pilot schemes underway in seven countries using an AC system,” says Yasmine Assef, the group’s energy new business director. “This requires inexpensive adaptation of the charging terminals and also reduces infrastructure

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roll-out costs, because the hardware is within the vehicle.”

Vincent Schachter, head of global energy services at Enel X e-Mobility, which is providing V2G units for projects worldwide, says the industry needs a standardized approach: “The development of V2G-compatible EVs has been slowed by a lack of communication standards for bidirectional charging, but emerging standards are expected to greatly impact scale and cost reduction.

“For a taste of things to come, we can compare this technology to solar power generation or stationary storage. In both cases, once an inflexion point was reached in the technology maturation and adoption



6

5. Nuuve has worked with Nissan on its first V2G hub in Denmark

6. Nuuve has also worked to give school buses in California bidirectional charging

“Deployment relies on fleets sharing sensitive information about their operations with project partners”

Dr Doros Nicolaides, senior consultant ULEV & energy, Transport Research Laboratory

curve, industrial scale and cost reduction happened quickly.”

Incompatibility isn’t an insurmountable problem as Nuvee has been working with OEMs on ways to share state-of-charge information via vehicle telematics systems, and Poilasne says pilot projects show the business case already exists. These have shown V2G can reduce EV ownership costs by around 25%, but that fleets are likelier to be earlier adopters due to consumers’ less predictable usage patterns.

Even businesses aren’t entirely reliable. During a field trial in Norway, Nuvee found users wouldn’t always return vans to the depot, affecting the power available for the grid. By comparison, the company is working on a trial

with Con Edison in New York State, fitting bidirectional chargers to electric school buses. These are parked 97% of the time and they offer a combined 75kW output during the summer, which reduces the seasonal demand spikes from air-conditioning.

“If there’s one thing that utilities agree on, it’s that the school bus is the killer application of V2G. There’s a significant upfront cost [for buses] for installation and integration into the grid. If you can finance it in the long run by using those vehicles to provide grid services, that will generate some revenue and pay for the cost of integration,” Poilasne adds.

However, Dr Doros Nicolaides, senior consultant ULEV & energy at the UK-based Transport Research Laboratory, adds that company policy could be as big a restriction as today’s incompatibility issues between back-office systems.

“Deployment relies on fleets sharing sensitive information about their operations with project partners, which can be a significant barrier,” he claims.

Power to the people

It’s yet another giant leap for end-users as Hugo Herrmann, V2G development engineer

IS WEAR AN ISSUE?

The potential downside of over-using bidirectional charging is an increase in the number of charge-discharge cycles the cells are put through. A recent Lawrence Berkeley National Laboratory report suggests this could reduce battery life by 10%, warning that it should only be called on when it’s absolutely needed.

However, the underlying technology – which enables remote monitoring of battery status – could allow much finer control, as Cenex’s Chris Rimmer explains: “Vehicle-to-grid potentially unlocks the ability to manage the batteries a little more effectively, which improves their lifetime performance and comes through in total cost of ownership. I think the jury’s out on that last point, but that would be a further push.”

Ricardo’s Julian Dunn agrees, adding that the typical 10kW output is a relatively tight load on the battery. “There could be limits around what state of charge you enable and how much power you could deliver each way,” he says. “Ultra-fast charging is likely to have a greater impact on battery degradation than modest V2G functionality.”



7



"Two years ago, domestic V2G units were the size of a fridge and cost more than £15,000"

Tom Pakenham, director of EVs, Kaluza

for EVs at EDF Energy's BlueLab, warns: "There is still anxiety surrounding the range in which vehicles can travel and whether we have the infrastructure to support this – as we are still in the early stages of the adoption curve with EVs, people need to be educated on the range of EV and infrastructure availability but also about how V2G charging works and about its added benefits."

But this is very cost-sensitive. A UK study by Cenex showed that revenue depends heavily on the amount of time vehicles are idle and not charging – and the relationship isn't linear. Vehicles plugged in 75% of the time could earn £436 (US\$562) additional annual revenue by moving from V1G to V2G. But that's four times higher than a vehicle plugged in 30% of the time.

So privately owned vehicles remain a vital ingredient, offering the volumes and downtime that suit V2G perfectly. OVO Energy launched the world's first domestic bidirectional charger in 2018, and Tom Pakenham, director of EVs at its smart charge subsidiary Kaluza, believes costs are becoming more consumer-friendly.

"Two years ago, domestic V2G units were the size of a fridge and cost more than £15,000 [US\$19,000]," he says. "They are now more commonly in the region of sub-£4,000

[US\$5,000] so we'd hope to see in the next two years the price reducing further, perhaps to £2,000 [US\$2,500]. If homeowners are then making around £400-£600 [US\$515-\$773] annually, we might see something similar to the solar market boom and a widespread uptake of the technology."

Which, in turn, shifts importance onto government policy as a catalyst. NewMotion CEO Sytse Zuidema highlights policies such as the UK's restriction of subsidies to cover only smart charge units as a good example, but legislation and taxation for EVs remains a hurdle. As the roadmap clears, it seems EVs could become an enabler for, rather than a barrier to, a greener grid. But not without cross-sector support in place. 



8

7. Kaluza's V2G unit is an example of how domestic units have come down in both size and price

8. A Nissan technician gets to work in Denmark

9. The car manufacturer's efforts are intended to help electric vehicles make the grid greener



9



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Ambitious GOALS

Jochen Hermann, vice president for eDrive development at Daimler AG, has already set the wheels in motion for the company to achieve its bold target of a carbon-neutral fleet by 2039, but there's still a long way to go and a relatively short time to get there

WORDS: JAMES BILLINGTON





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Daimler is on a mission. The automotive manufacturer has set itself the target that in less than 20 years it will have a completely carbon-neutral new passenger car fleet, and by 2030 have more than half of its sales come from plug-in hybrids or fully-electric models.

It's all part of its Ambition2039 goal, which involves a holistic approach to how its business can deliver sustainable mobility by this date. For a company that has been a purveyor of internal combustion engine vehicles for the past 130 years to achieve this target, it takes massive organizational shifts in strategy, investment and resource. Over US\$11bn will be invested to put a range of EVs into production over the course of the next few years and also spend a further US\$1bn on battery manufacturing.

It's rolling out a three-track approach to electrification and recently launched the EQ moniker – a badge to indicate models of vehicles having either a 48V electrified engine, a plug-in hybrid, or all-electric or fuel cell powertrain.

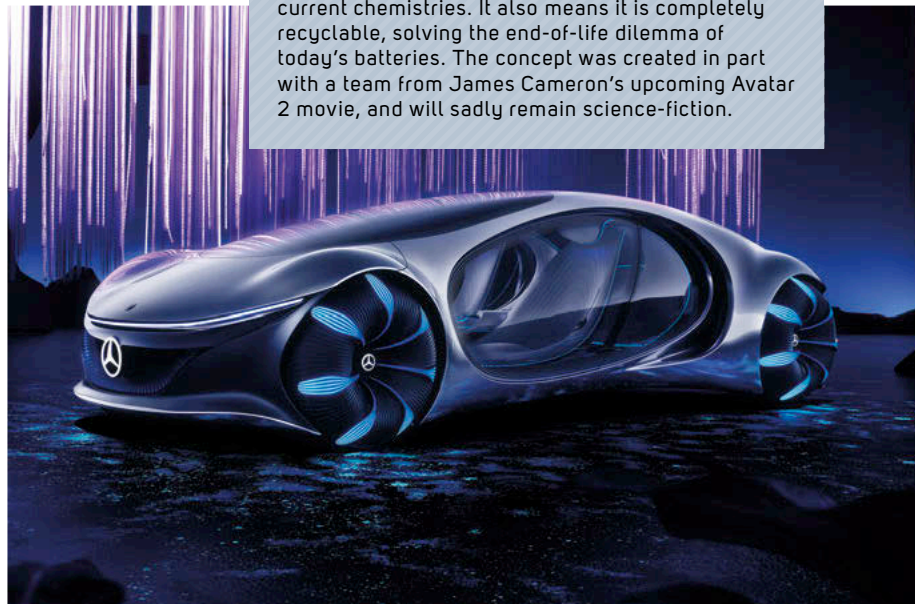
As well as the vehicles themselves, Daimler is a committed to more sustainable ways of manufacturing. With renewable energy, such as wind power, already being used at several production sites, its ultimate target is for all of its European plants to be CO₂-neutral by 2022.

With Daimler's sights set on the goal and the deadline to achieve this racing towards it, the company's aggressive push is moving at an electrifying pace and Jochen Hermann, vice president of development for eDrive at Daimler AG is in the front seat. Responsible for the electric powertrain components for electric mobility he ensures their system integration within Mercedes-Benz vehicles. This includes advances in both battery technology and fuel cells, and he is also responsible for the overall development of the new electric vehicle architecture. With the group planning a total of 10 all-electric cars in the next years, he has his work cut out.

1. Daimler AG's line-up of electrified commercial vehicles including buses, trucks and LCVs

VISIONARY IDEA

Beyond 2039, Mercedes-Benz engineers are looking way into the distant future of what an electric vehicle might look like and be powered by, with the Vision AVTR (Advanced Vehicle Transformation) concept car. Shown off at the 2020 Consumer Electronics Show, the groundbreaking vehicle is a luxury saloon with four near-wheel-built electric motors with a combined power of more than 350kW. The power and movement of the wheels can be individually controlled to enable the vehicle to move sideways. If that's not impressive enough, its battery is based on graphene-based organic cell chemistry, which eliminates rare and toxic materials found in current chemistries. It also means it is completely recyclable, solving the end-of-life dilemma of today's batteries. The concept was created in part with a team from James Cameron's upcoming Avatar 2 movie, and will sadly remain science-fiction.



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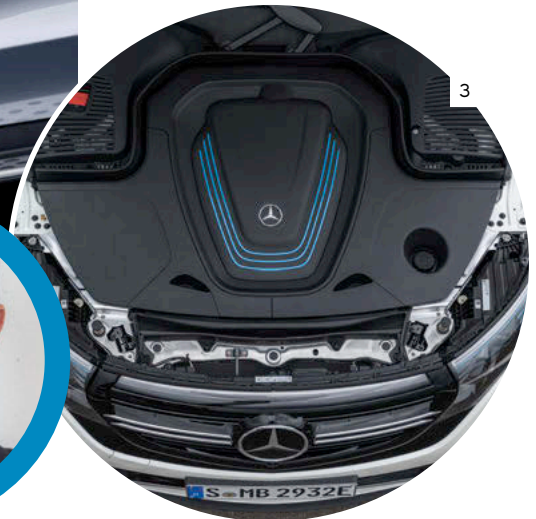


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3

How is the philosophy at Daimler changing as a result of the electrification movement?

In ten years from now, in 2030, 50% of our sales will be either plug-in hybrid or fully electric, which is a bold statement from us. This is something that we started from the development side with a strong push for electrification. If you look at our portfolio this year with the plug-in hybrids, they're employing third generation technology, for which our engineers have done an incredible job of putting in as much energy as possible in a given space within the car. If you look at our previous generation, we admit we had to make sacrifices on the truck volume and range. One of the main drivers for us is giving customers the opportunity to go electric and emission free – we're not a startup vying for customers, we have people ready and waiting to electric.

What were the biggest obstacles and technical challenges with electrifying the company's line-up?

For over 130 years internal combustion engines have been our business, so when we started to get serious about electrification the battery was one of the biggest technical considerations we had to deal with. We discovered that when thinking about they could do and solving problems around the space deployment for batteries, it involves a lot of mechanical engineering. We are a company that started manufacturing battery cells and then we realized that the cells have to be specifically designed for the application,

"When we started to get serious about electrification, the battery was one of the biggest technical considerations we had to deal with"

2. Daimler has invested US\$11bn into its EQ portfolio, and aims to put over 10 different fully-electric vehicles into production by 2023

3. Daimler engineers have worked alongside suppliers to develop its battery technology

4. The Mercedes-Benz EQC is the brand's first fully-electric SUV

however, there is a lot that can be done with the module and pack design, which transformed a lot of our existing engineering staff into battery mechanical pack designers. We have made major progress over the last few years and have been able to get more density into the batteries, making available space, and also on the production side where we have been breaking down costs to make sure one production line can produce several pack designs.

Where do you see battery chemistry going?

Looking at everything as a whole, lithium-ion technology is the standard technology until at least 2025. Ourselves, and the entire industry are striving for solid-state technology, but that won't happen for some time. Before 2025, what we'll see is the optimization of the battery – bringing down the levels of cobalt, increase performance and density and bring down costs. Fortunately, compared to other components of the car, we're relatively at the beginning of this technology and there's opportunity to make them better.

Are you working on batteries in-house or with suppliers?

We're working with suppliers as they have to manufacture the cells but the team we have on the production side we brought together with the engineering side so we increased the engineering power of the cell component, chemistries and production processes. We want to talk eye-to-eye with our supply companies as we want them to make the cell very specific. On the other hand, we want to



4

reduce their existing investment to bring down the cost. We challenged our production teams to make use of the investment – there are huge factories making tons of battery cells, so we had to look for the best to partner with. It's a Mercedes philosophy that no matter if we make it or buy it, we always are involved in the engineering.

There was a time not long ago when people didn't want to touch diesel, but you've introduced it to PHEV variants of the GLE and GLC – do you see a future for it then?

It depends on segments, but I do believe there really is a future for diesel. We have markets where people love diesel as it fits to their driving needs. The GLE diesel PHEV combines two perfect drivetrains for that segment. Diesel is very efficient for CO₂ and long-distance driving, and with the EV range the cars offers, we can cover the needs for the average daily drive and long distance by combining these two technologies.

We have the cleanest diesel available in the market and if we're talking CO₂ targets, which is a good thing, then diesel is an important part of this. Sometimes discussions around diesel can be more emotional than rational.

What is your electrification strategy surrounding commercial vehicles?

We have a number of electrified trucks and buses on the commercial vehicle side, but fuel cell

6



technology is important too. If you look into commercial applications I see long-haul truck driving makes much more sense with a fuel cell than battery; but if you look at local area and city goods transportation, then a battery-powered truck is a more valid option. In an industry where things change a lot, you have to have a balanced strategy – no one system fits all.

What were the business case and development discussions around light commercial vehicles (LCVs) and what were the technical challenges behind modifying an existing product with the EQV?

We see a demand with city limits and local emission-free driving, but ultimately it comes down to our Ambition2039 target, and if you want to electrify the whole company, you have to look at vans. Vans are a big part of our business, you can get a lot of people in one van and they are an efficient way of transporting people from A to B.

From an engineering point of view, they are good for battery integration without sacrificing any space within the cabin because they are big already. Also, something to consider was to make sure our existing production lines can handle the vehicle, because then we are able to be flexible and take advantage of all the existing quality controls and volume production [already on-site]. We did this also for our EQC fully-electric SUV.

Is there anything you would like to change about the industry to help meet your 2039 target?

There is not one thing, but several things that need to change, and they are all interlinked. Technically, it would be battery technology, but I'm very confident we will see big changes within the next 10 years. Infrastructure is also definitely something that society should think about.

But if I had one wish, I want everyone to start talking about the advantages of CO₂-neutral mobility and for the industry to think about car design. We have a lot of information on the table about how we want to achieve our goal in 2039, but we have to do that within three model cycles, which isn't a lot for the car industry. 



8

6. By 2030, Daimler aims to have half of its sales come from hybrid or fully electric vehicles

7. Existing production lines had to be adapted to accommodate the EQC

8. Daimler's EQ brand signifies its range of electrified vehicles

9. Electric LCVs are a big part of Daimler's strategy

9





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The trend towards the robotization of the automotive production line is taking a new form. Manufacturers are starting to use collaborative robots – or “cobots” – in many applications instead of the fast-moving, caged-off industrial robots that have been the traditional solution for automating the factory floor.

Since they’re designed to work with a human operator, cobots like Omron’s TM Series are a great way for manufacturers to automate repetitive tasks while harnessing the human creativity required to stay flexible. As companies strive to produce multiple vehicles on the same line to adapt seamlessly to market changes, flexibility is key.

Cobots are quite easy to program, often featuring intuitive hand-guided teaching that even novice operators can easily

learn. A wide variety of end-effectors can be used for pick-and-place, gluing, soldering, and other tasks. Omron’s TM Series also employs integrated vision and 3D positioning to respond to new situations as they arise during production.

With a highly adaptable design, cobots can be redeployed to almost any task in almost any workspace without requiring changes to production layouts. The Omron TM Series’ intelligent use of vision eliminates the need for complex, rigid fixtures that confine parts to extremely specific placement.

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WIRED

Electric propulsion systems are not only due to shake up the passenger vehicle segment – they could also revolutionize the battlefield in the coming decade

WORDS: **LEON POULTNEY**

We could soon see increased levels of cutting-edge technology used by global militaries in an attempt to improve safety and performance on the battlefield. Electric powertrains are one example.

“Some defense vehicles are approaching 30 years old. They were designed for a different era, using technology that’s now outdated,” says Dr David Moore, campaign director of electrical propulsion & drivetrains at QinetiQ. “Forces are turning their thoughts to the next generation of vehicles, and how they can take advantage of new technologies to improve mobility, survivability and automation.”

The company, which recently won two contracts from the US Office of Naval Research to develop its proprietary hub drive unit



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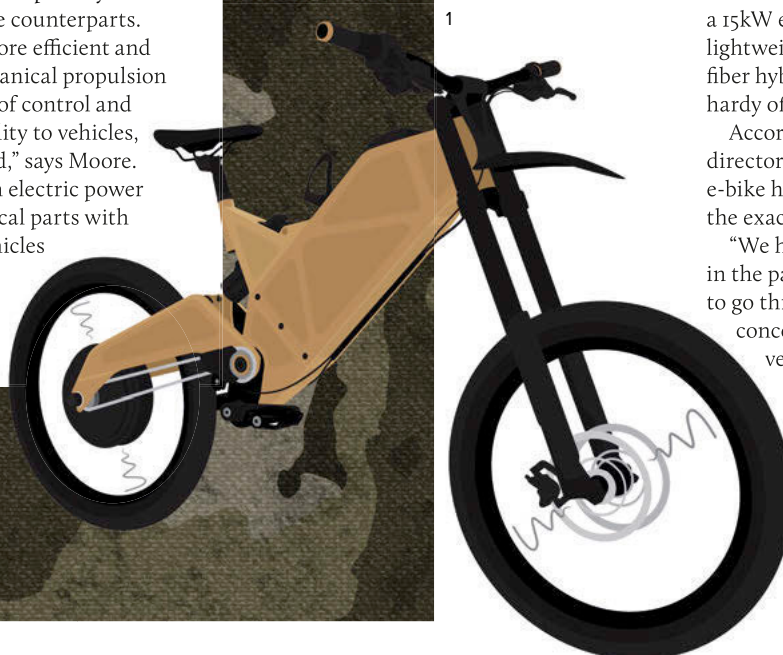
electric propulsion system and long travel suspension for use in armored reconnaissance vehicles, is well along the road to creating bespoke electronic hub motors that could soon feature in military ground vehicles.

Its main innovation has been around an electric hub drive unit, which combines a compact electric motor with a multi-stage gearbox and integral brake that fits inside a standard 20in wheel.

More importantly, it is able to operate at either high output speed or high output torque, unlike other conventional single-speed and fixed-speed hub drives. In a military setting, this offers unprecedented freedom in terms of design and instantaneous performance when required.

Placing a motor within the wheel (or wheels) eliminates the need for bulky transmission and drivetrain components, while the high output torque and high output speed is designed to match or exceed the current capability of internal combustion engine counterparts.

"Electric propulsion is more efficient and reliable than existing mechanical propulsion and allows a higher degree of control and startup speed, bringing agility to vehicles, while reducing fuel demand," says Moore. "It can replace engines with electric power sources, and fixed mechanical parts with flexible cables, allowing vehicles to be designed around intended use rather than engineering necessity."



"Typically, military vehicles have to be able to withstand levels of submersion in water that go way beyond anything a normal passenger vehicle would have to experience"

Raphaël Caillé, managing director, Swindon Powertrain



1. The Swind EB-01 electric bike is lightweight and rugged thanks to an aluminum and carbon fiber shell, while a 15kW motor provides plenty of power for all types of challenging terrains

e-bike revolution

The humble bicycle has long been used by armies as a quick, light and efficient way of getting around. During World War One, Italy used the basic two-wheeled transport with its Bersaglieri (light infantry units) until the end of the war, while the Finnish Defence Forces still trains all new conscripts to use a bicycle to this day.

Spanish trials bike manufacturer Bultaco has enjoyed a recent resurgence by shifting its focus to powerful e-bikes, and its latest off-road Brinco model has been trialed and tested by numerous armed and security forces as a viable mode of transport.

In the UK, Swindon Powertrain's first foray into electric vehicle concepts was also a rugged e-bike in the form of the EB-01. Powered by a 15kW electric motor and featuring a lightweight but tough aluminum and carbon fiber hybrid shell, it bridges the gap between hardy off-road motorcycle and pushbike.

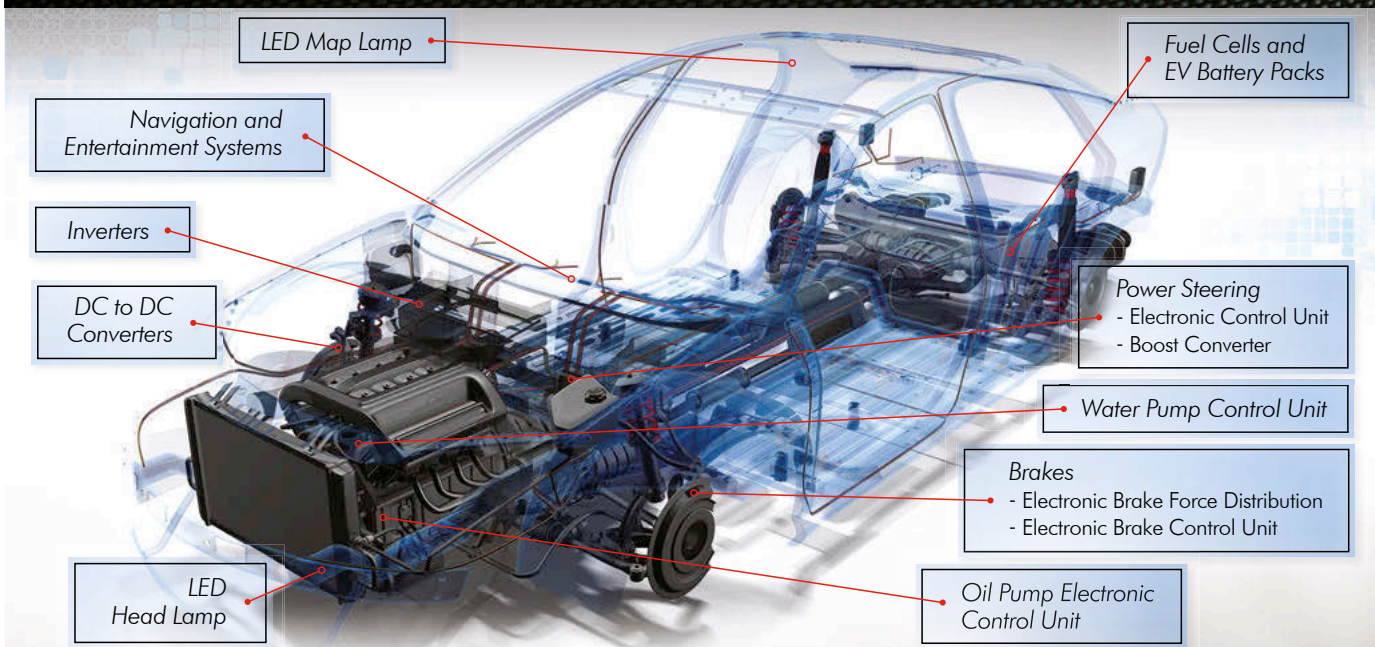
According to Swindon Powertrain managing director Raphaël Caillé, the cutting-edge e-bike has the potential to be modified to meet the exacting standards of the military.

"We have worked on other military products in the past, so understand what vehicles have to go through to take it past the point of concept stage," he says. "Typically, military vehicles have to be able to withstand levels of submersion in water that go way beyond anything a normal passenger vehicle would have to experience. This presents a real engineering challenge when it comes to packaging batteries and electric motors but it is no harder than anything we have experienced with the internal combustion engine."



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2. The Silent Utility Rover Universal Superstructure (SURUS) is an autonomous vehicle that uses fuel cell propulsion. The commercial vehicle platform designed by GM can be adapted for military use

3. The fuel cell features instantaneous high torque, exportable power generation, water generation and quick refueling times

In addition to this, Raphaël reveals that the company is also set to release a new and highly innovative 80kW 'crate' High Power Density (HPD) EV system, designed to act as a turnkey powertrain solution for low-volume cars and light commercial and recreational vehicles.

"To date, niche manufacturers have not had access to compact, high-power EV powertrains they could source in low to mid volume, leading to a vacuum of supply," says Caillé. "When you factor in development costs, specialist OEMs haven't been able to electrify their vehicles as quickly as they would like. Our ready-to-install 'crate' powertrain will accelerate EV adoption in sectors poorly served by the larger Tier 1 manufacturers and integrators," he adds.

Although not directly ready for combat use just yet, Caillé points out that the compact 600mm x 440mm x 280mm motor, inverter, transmission and cooling system assembly fits in a quad bike or under the loading platform of a van, so could easily be converted for military vehicles with additional engineering elements.

A marriage of technology

The head of the British Army, General Sir Mark Carleton-Smith, recently announced a new £3.2m (US\$4.1m) project, led by the Defence Science and Technology Laboratory (DSTL), which would focus on electric drive systems for future tanks and robotic vehicles in a bid to make warfare more 'environmentally friendly'.

As paradoxical as that sounds, fuel efficiency is a hot topic for those military forces that face budget cutbacks and a decreasing level of funding at a governmental level.

But as QinetiQ's Dr Moore points out, electric propulsion can do more than simply

3



make vehicles more efficient – it can also enable and support emerging technologies.

Autonomous driving is one such innovation that armed forces are taking very seriously, due to the fact that it removes personnel from the theater of conflict and massively reduces the danger to life.

"Replacing engines and mechanical drive shafts with electrical power sources and motors allows a single system which combines propulsion with sensors, controls, on-board computers, communications and targeting systems," describes Moore. "Electric propulsion is therefore a vital part of a broader move towards increased electrification and autonomous vehicles."

However, the current power density in battery packs and the issues of charging on the battlefield are still issues that military Tier 1 suppliers are still trying to resolve.

The US Army has long relied on JP-8 aviation fuel for many of its larger vehicles, but several companies are already looking at the viability of hydrogen fuel cell technology, chiefly due to the energy density benefits and the relative ease at which fuel can be transported.

GM Defense recently unveiled a military-spec fuel cell vehicle based on the company's road-going Silverado model. The Silverado ZH2 boasts a range of 400 near-silent and

4. The Chevrolet Colorado ZH2 by General Motors is an extreme off-road-capable fuel-cell-powered electric vehicle

5. GM's hydrogen fuel cell technology is currently being tested by the US military to determine its viability for future use

emissions-free miles, with water the only thing emitted from the tailpipes.

But more importantly for military use, these hydrogen fuel cell vehicles could also act as transportable generators for auxiliary systems, such as radar and weapons-controlling computer networks.

David Albritton, president of GM Defense, told the USA's *National Defense Magazine* during a military forum earlier this year: "If you think about operators at the pointy end of the spear, their power source today is mostly dragging along heavy diesel engines.

"They have an odor. They're loud. It's a very inefficient way to create power. With our product, not only can you take the vehicle and power the vehicle from point A to B, you can then export that power for a variety of usages."

Ahead of security

Alongside the developmental issues surrounding electric vehicles for military use, there is also call from the cyber security industry for increased levels of protection in electric vehicles.

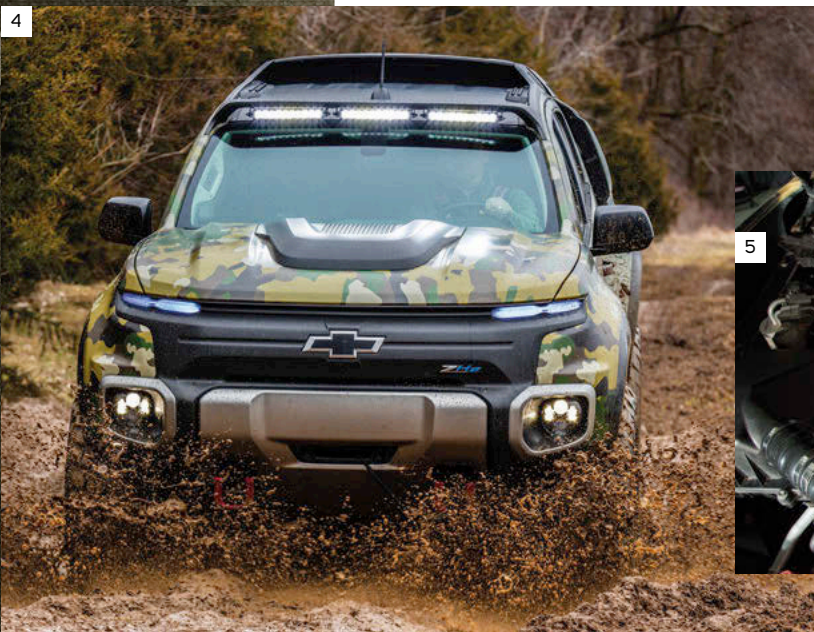
Leading cyber security expert Kaspersky Lab has been vocal about the vulnerabilities of EVs and the resulting issues that arise with neglecting this subject.

In one experiment, Kaspersky Lab experts discovered that electric vehicle chargers supplied by a major vendor carried vulnerabilities that could be exploited by cyberattackers, and that the consequences of a successful attack could include damage to the home electricity network.

Although these military concepts are highly unlikely to ever employ the use of a domestic charging network, innovators in the combat vehicle field understand the risk to any connected system in today's age of modern, technology-based warfare.

As a result, institutions such as NATO have been holding regular 'live fire' drills that simulate cyberattacks on military networks. NATO's Locked Shield Exercise pits some of the most talented hackers in the world against one another in an annual simulated cyberattack scenario to ensure it continues to stay ahead of the threat.

To the consumer's eye, development in the passenger car EV market might seem slow and steady, but with multi billion-dollar contracts on the table for military innovators, electric propulsion will lead the charge onto the battlefield of the future. 



"Electric propulsion is more efficient and reliable than existing mechanical propulsion and allows a higher degree of control and startup speed"

Dr David Moore, campaign director of electrical propulsion & drivetrains, QinetiQ





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Inner **SPACE**



Vehicle interior design is entering one of its most exciting and transformative eras as the move to electric powertrains presents a number of opportunities to enhance cabin proportions and create more intuitive layouts

WORDS: GUY BIRD



The huge potential to change vehicle design due to the introduction of all-electric powertrains – which barely need a hood nor a transmission tunnel and thus rearrange proportions to unlock more interior space – has been an opportunity that carmakers have rarely maximized. While the BMW i3 and Jaguar I-Pace are two exceptions, in some cases OEMs have elected to keep the exterior form of their all-electric vehicles similar to existing internal combustion engine (ICE) vehicles, so as not to shock or unsettle early EV adopters with a new design as well as powertrain. And in other cases the reason has been more about pragmatism. Because automakers have been unsure whether early EVs would sell in large numbers at the higher prices required to cover the costs of expensive batteries, they have often made sure those cars could also accommodate (cheaper) regular engines, or indeed in the case of hybrid and plug-in hybrids, a combination of the two power sources, as well as being manufacturable down the same production line.

But as a direct result of dieselgate in late 2015 – when Volkswagen's emissions-test scandal was uncovered, progress towards dedicated new electric platforms accelerated. "We had the diesel issue, and our boss Dr Diess asked to see an electric family. This was in 2015," explains Klaus Bischoff, VW brand head of design. "There was a meeting with 42 top managers of which I was one, to come together over the weekend for a



1. The Porsche Taycan uses innovative battery placement to create more space in the rear footwells

2. The new fully-electric VW I.D.3 is built on a modular platform that provides a larger, usable interior space

3. 3D touch surfaces and textiles can replace many physical controls and dials



"We had to do something completely different, to rethink our brand. The result was to create a new Volkswagen with emission-free mobility"

Klaus Bischoff, head of design, Volkswagen



3

workshop to think about what we do next. We had to do something completely different, to rethink our brand. The result was to create a new Volkswagen with emission-free mobility. After four weeks we had to come up with a family. We couldn't create models in that time, but we made full-scale drawings on paper showing the family at our presentation hall. All the

[resulting] ID concepts at the 2019 Frankfurt Motor Show were part of that presentation. When the I.D.3 was done, the idea of the platform with a fully-electric battery between a long wheelbase with short overhangs was developed, to get the proportions right. Then the process started across the VW Group brands, as it was a huge investment."

The all-electric platform that underpins all the forthcoming models is known as MEB (Modularer E-Antriebs-Baukasten) and will spawn not just the next generation of VW EVs – starting with the I.D.3 hatchback in mid-2020 – but numerous Seats, Skodas and Audis too. This platform could equate to millions of full production EVs on the road within the next decade. But arguably from an EV layout point of view, moving the front axle and firewall forward gives benefits of a larger, usable interior space.

Smart design

Where the Group's designers are innovative with MEB is the one that hosts the production Porsche Taycan and the forthcoming Audi GT e-tron. One key innovation is the hollowing out of rear footwell space in the otherwise rectangular battery pack by moving some of the batteries to the outer edges of the car to allow more room for the rear passengers' feet, allowing them to sit deeper within the car and enable a lower roofline more in keeping with a performance sedan. A further scalable VW Group Premium Platform Electric architecture

"Any surface can be smart and aesthetically integrated, saving space and weight"

Juha Kokkonen, CEO, Canatu

MATERIAL WORLD

Electric powertrains present several challenges to interior designers, whether the need to be lower vehicle weight to maximize efficiency or combatting the effects of ambient noise as a result of the absence of an engine. Lightweighting is a big area of focus with advanced textiles able to shave off vital kilograms to increase driving range. It is estimated that a 10% reduction in vehicle weight can result in an 8% increase in driving efficiency.

Nissan has addressed both of these concerns with one single product, thanks to the introduction of a new lightweight sound insulation material called acoustic meta-material, which was revealed at this year's Consumer Electronics Show in Las Vegas.

Designed to make the cabin quieter while also boosting energy efficiency, the advanced material, which has been in research since 2008, uses a combination of a lattice structure and plastic film that suppresses air vibrations to limit the transmission of wide frequency band noise such as tire noise from road surfaces. Nissan claims the new material weighs only a fourth of the heavy rubber materials that are typically used for sound insulation, while providing the same level of performance.

As a result of its simple structure it can cost the same, or possibly cheaper to mass produce than current materials, meaning it can be applied to more areas of the cabin where sound insulation is currently limited due to cost.

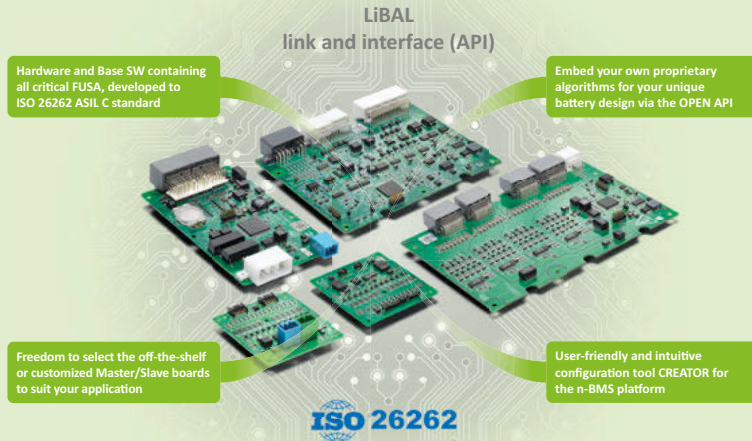
(PPE) will be used for future full-size and luxury models. Standard models will get an electric motor at the rear while high-end versions will gain a second electric motor on the front axle, plus be able to accommodate different battery sizes and therefore mileage ranges. The architecture will also allow for low and high-floor vehicles from upper-medium cars to luxury SUVs, estates and crossovers.

Automotive supplier Canatu believes EV interior design can also benefit in less obvious ways. "The replacement of air ducting with a new type of panel heater creates significant saving in space between



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engine compartment and front seats,” says Canatu’s CEO, Juha Kokkonen. “This enables either more space inside the car, or even smaller cars. Also the floor space can be more flat. With more space created, interior designers can design more comfort features inside the car.” Which is also where Canatu comes into its own, as experts in 3D touch surfaces which could soon replace many physical mechanical controls. “Any surface can be smart and aesthetically integrated, saving space and weight,” Kokkonen continues. “3D touch can be integrated with plastic, textile, leather or glass and in door controls, center consoles, steering wheels and roof modules. As the 3D touch surfaces are software-based, you can design one surface to serve several functions.” Nearer term, the interior design of the VW I.D.3 has also been simplified by using fewer materials. Sit inside the brand’s first bespoke EV and it is a pleasingly pared-back space with little ornamentation or added surface treatments, but one based on much more than minimalist aesthetics, as Bischoff explains: “It’s about the democratization of electric mobility to get the price point down and also at the end of its lifespan it’s then easier to dismantle and recycle. If you use materials in a combined way it’s much harder.”



On the outside

Other vehicle makers are also grappling with how to make good-looking EVs with good interior space, beyond short-range city cars



“The problem of electric cars for a designer is that you have [to accommodate] six inches of battery pack”

Gorden Wagener, chief design officer, Daimler

such as the Honda e and Mini Electric with smaller battery packs, and medium-to-large SUVs which can cope with larger battery packs because they still have high rooflines. Chief design officer for Daimler, Gorden Wagener explains why its Mercedes brand has chosen to produce two luxury limousines – including an all-electric limo based on the EQS concept shown at the 2019 Frankfurt motor show. “The problem of electric cars for a designer is that you have [to accommodate] six inches of battery pack, so six inches worse in height proportion,” he explains. “We did the exercise, with a three-box sedan, adding six inches to an S-Class. It did not look good.”

The solution was to take inspiration from the cab-forward F 015 concept of 2015 but extend the wheelbase and apply what Wagener calls a “one-bow” side silhouette, like the gentle

4. Mercedes is releasing an all-electric limousine based on the EQS concept (pictured) that has had to completely redesign its exterior and interior proportions due to the addition of the battery

arc of a rainbow. “The advantage of this ‘one bow’ design is you end up with like really straight, fast lines that are very significant for Mercedes, but also make the vehicle look low, sleek, efficient and aerodynamic.” In reality Wagener says the EQS is slightly taller than the current S-Class, but doesn’t appear so due to the longer wheelbase, which in turn has the benefit of offering more interior space than the long wheelbase S-Class, and also because of its generous 24in rims, which ensure a great wheel-to-body relationship.

Jaguar’s new design director Julian Thomson says the brand’s forthcoming all-electric XJ limo will feature similarly large wheels to help proportions. As there’s been no concept to preview its arrival in 2020, Thomson wouldn’t quite reveal all but expect lightweight aluminum in abundance and other tricks besides: “We have some technology solutions. I won’t tell you what they are, but luckily electric cars do tend to weigh a bit [due to the heavy extra batteries] so they need huge wheels and tires so you can offset certain things. But I think we’re going to offer an electric car with a much larger interior than we think anyone else is doing and much larger than our current XJ.”

“We’re going to offer an electric car with a much larger interior than we think anyone else is doing”

Julian Thomson, director of design, Jaguar

5. Audi’s e-tron GT concept is based on a flat-floor architecture with its battery placed between the front and rear axle to create more cabin and leg space

These varied approaches to EV interior design, born from a mixture of range-extending necessity to packaging and aesthetic opportunity, have the potential to reduce weight, improve recyclability and create more space while still retaining an appealing design. And as more future vehicles become electric-only from the start – rather than adaptations of existing combustion-engined cars – and increasingly autonomous, negating the need for traditional dashboards, driver displays and eventually steering wheels too, this sort of EV design ingenuity is only set to increase. As Volvo’s design VP, Robin Page enthuses: “The next few years for any interior designer will probably be the most exciting time since we converted from coaches to cars.”

“The next few years for any interior designer will probably be the most exciting”

Robin Page, VP of design, Volvo Cars



5



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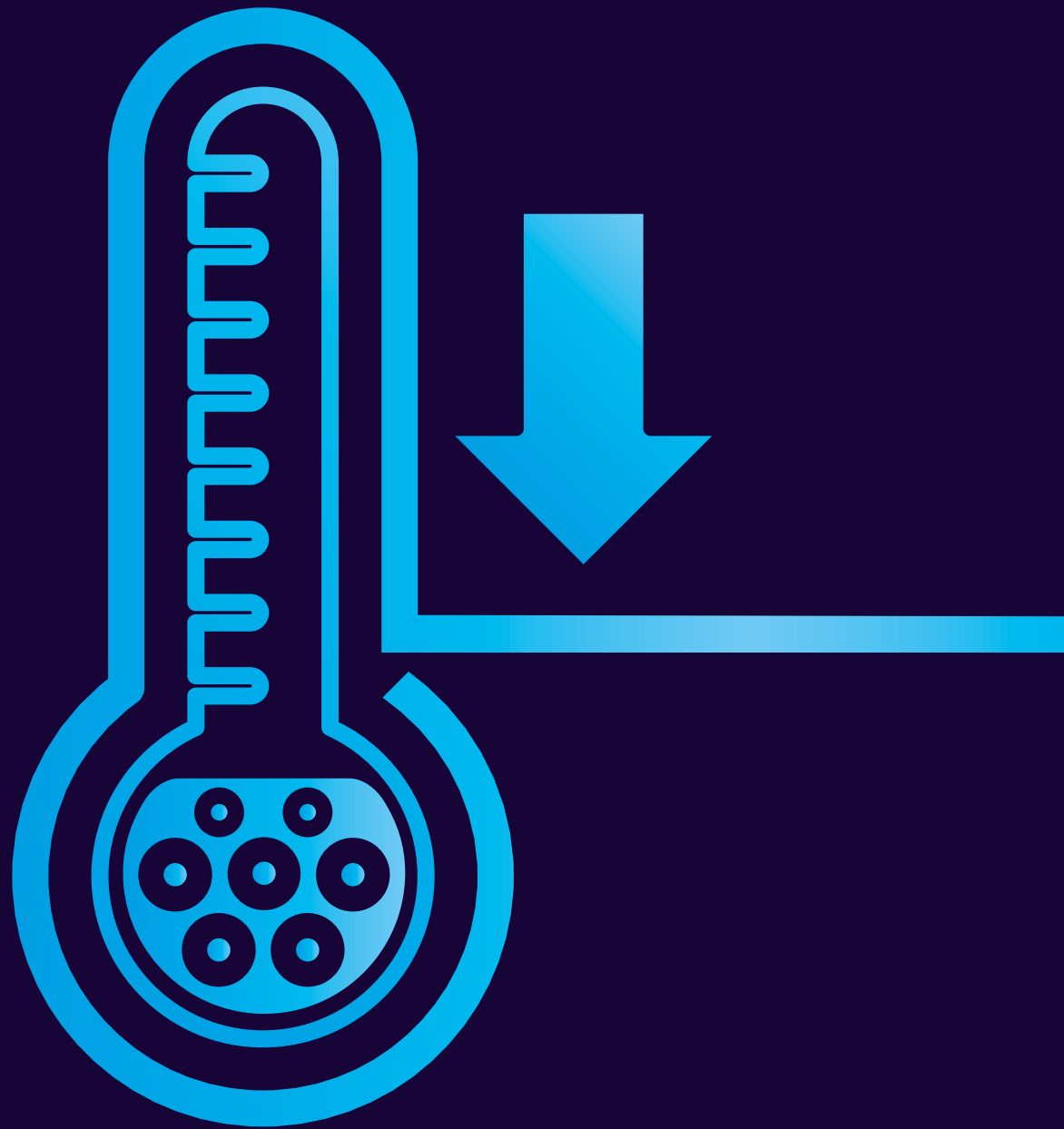
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KEEP COOL

AND



CARRY ON

The move to higher capacity
batteries and faster charging is a
big step forward for EVs, but it does
come with other challenges

WORDS: **JOHN CHALLEN**

Of all the facts and figures produced by manufacturers about new electric vehicle models, often the one that most interests potential consumers is how long the car's battery takes to charge. Having been used to instantly refueling an ICE-powered vehicle, waiting around for the car to regain its power can be a shock to the system, but with fast-charging technology, the situation is improving.

The increased rate of charging isn't without issue though, one of which is an increase in the temperatures found on the equipment. The charging station itself isn't affected by the move from 50kW to 350kW – it's the ancillary components that bear the brunt and have to be controlled.

"Cables and connectors on EV chargers were designed for much smaller currents compared to those now being put through them. So the challenge for us is keeping the copper cable and the surface temperature of the outside cool enough for people to comfortably use," says Dr Suzanne Koblitz, head of charging technology at Ionity. "The cooling systems and cables are pretty standard, but the challenge is new to the automotive industry. People are having to get used to it because these cooling systems haven't been in the industry before."

Although Ionity merely buys and installs chargers, Koblitz' knowledge comes from a previous role where she

was responsible for writing the standard for cooled charging cables. The biggest issue is that when the copper in the cable gets too hot due to the level of power being run through it, the efficiency drops, the rate of charge slows and suddenly fast-charging becomes much more medium-paced.

"The most important change – and where most of the development has been – has been actively cooling down the contact system, which is the point where the connector and the vehicle meet," she explains. "There is a lot of heat generated at that point and you have to cool something that has up to 1,000V. It needs to have the electrical isolation, but at the same time cool the connectors." Koblitz says that the key elements to ensuring this cooling is achieved are special connector designs for high-power cables as well as hoses that carry coolant through the system. "You essentially have a cooling body added to the connector that takes out the heat of the connector system. This cooling body enables the heat to be regulated thanks to the coolant."

Excessive heat can impact on the efficiency of the cables and so can damage them, either



1



"The challenge for us is keeping the copper cable and the surface temperature of the outside cool enough for people to comfortably use"

Dr Suzanne Koblitz, head of charging technology, Ionity



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COMMERCIAL SUCCESS

The widespread adoption of battery-powered electric vehicles has been successful in the passenger car market, but in the commercial vehicle sector it's a different story. But manufacturers such as MAN, Renault Trucks and Mercedes-Benz have introduced electric trucks in limited numbers – often as part of trials – and work on faster charging technologies is ongoing.

"In the future, I don't expect huge developments with cables but there will be with HGVs," predicts Suzanne Koblitz. "It's clear that the charging power of 1MW or more, which is required by commercial vehicles, could not work with the existing connections from a reliability or safety point of view.

"Vehicles in the 26 to 40-ton range will need an independent system with a larger connector – that is very clear," she adds. "The conceptual discussion is how we manage to get an integrated system that covers the entire spectrum from 3.5-tons to 44+ tons. I'm a big fan of finding a solution where the intermediate vehicles are; find the possibility to go to a charging station that are also designed for passenger cars. But all of that is being discussed at the moment, but it's not clear in what direction it is going."

Max Göldi says that Huber+Suhner is also working on solutions for truck and bus, where the handling issues play a big role. "There is a working group for trucks and buses trying to define a charging interface and it is looking at loads of between 1,000 and 3,000MW, which is huge," he reveals. "Even 500kW is new territory for everyone in terms of vehicle charging. But with 2,000MW, safety is paramount as is the need to keep the cables the smallest possible diameter to make it easy to handle," he adds. "Automation will be possible in the future, but today it's important for human beings to physically charge the vehicles."



1. The Porsche Taycan is the first production vehicle to use an 800V system, instead of 400V, meaning faster charging, lighter cables, less heat and more efficiency

2. Ionity's 350kW high powered charging has had to solve the issue of heat generation by using coolant and special connector designs

intentional or accidental. "Maintenance is a big issue because charging cables have to be replaced regularly," says Koblitz. "The standard lifespan for a charging cable is 10,000 lifecycles – they are designed for this but are subjected to vandalism or are damaged when run over if left on the ground. We have to ensure cables can be replaced, roughly every one to two years, but I know other providers replace cables every one to two months because that is the only way to guarantee the level of reliability. So instead of waiting for a problem, they will categorically change all the cables on a strict schedule."

Koblitz admits cost is an issue and estimates that the cables required for fast-chargers being in the region of four to five times more expensive than standard items. "It's a new technology and there was a lot of engineering involved to bring the solution to the market," she reasons. "We don't have high volumes at the moment, either. Ionity has around 160 sites live and with four to six outlets on each site, which is under a thousand cables. There are more from other providers, but it still isn't a huge volume."

Supply side solutions

Fiber optic cabling company Huber+Suhner got involved in high capacity charger cabling for EVs around five years ago when German OEMs got in contact, asking about the charging infrastructure. "We started to think about possibilities of how to reduce the cable's diameter size because 350-500kW charging units require a large copper diameter," explains Max Göldi, market manager industry, low frequency division at Huber+Suhner.

"We needed a different solution to standard copper cable because for high-power charging, it wouldn't be difficult for the average customer. The target from the OEM was

the same experience that you'd have when filling your car with fuel, which is quick, easy and manageable."

What followed was Huber+Suhner's Radox HPC 400, a cable with a smaller diameter than before and a cooling system that directs the coolant to the connector first – initially around the pins and then all the way back directly on the copper wire. "The maximum temperature the pin can be is 90°C [194°F]; the cable surface, 60°C [140°F] and the connector itself, 45°C [113°F]," says Göldi. "If it is not being cooled, the system would completely overheat and burn the cable within a few minutes."

"There are different ways to cool. We evaluated all the possibilities and decided to use non-conductive coolant, which means we don't have any insulation issues with the coolant," he adds. "The big advantage we have is that we can cool directly on the copper. We start the cooling around the pins and on the way back to the charging station we're cooling the copper, so the hottest temperatures of the copper or the coolant is in the charging system."

Göldi reveals that the next generation of the cable – Radox HPC 500 – is set for release in early 2020, offering better cooling performance and efficiency. The cables will also be cooler and more lightweight, which further improves the operational aspect. "The first development was focused on safety and functionality, and now efficiency, flexibility and serviceability are the main focuses," he explains. "One of the weak points was the design of the interface of

the connector – that will now be easier to replace, because the design itself cannot be changed."

A price to pay

With the cooling issue under control and the rollout of fast-chargers continuing, Koblitz sees further improvement and more manageable costs for the units in the future. "I don't think the cooling system itself is a big issue in terms of cost for a high-power charging station. It's a contribution but not the main cost. The cooled cable is not the largest cost contribution and, while the difference in investment shows in the price the consumer has to pay, they get a different service and offer," she reasons. "Instead of charging at home every night, they can come to one of our sites, charge for 15-20 minutes and then potentially give them 400km [248 miles] of range." □

3. Huber+Suhner's Radox HPC directs coolant to the connector pins and back through the copper wire

4. Cables have been specifically designed to not melt at high temperatures or see any insulation shrinkage



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Vehicle Modelling and Virtual Testing

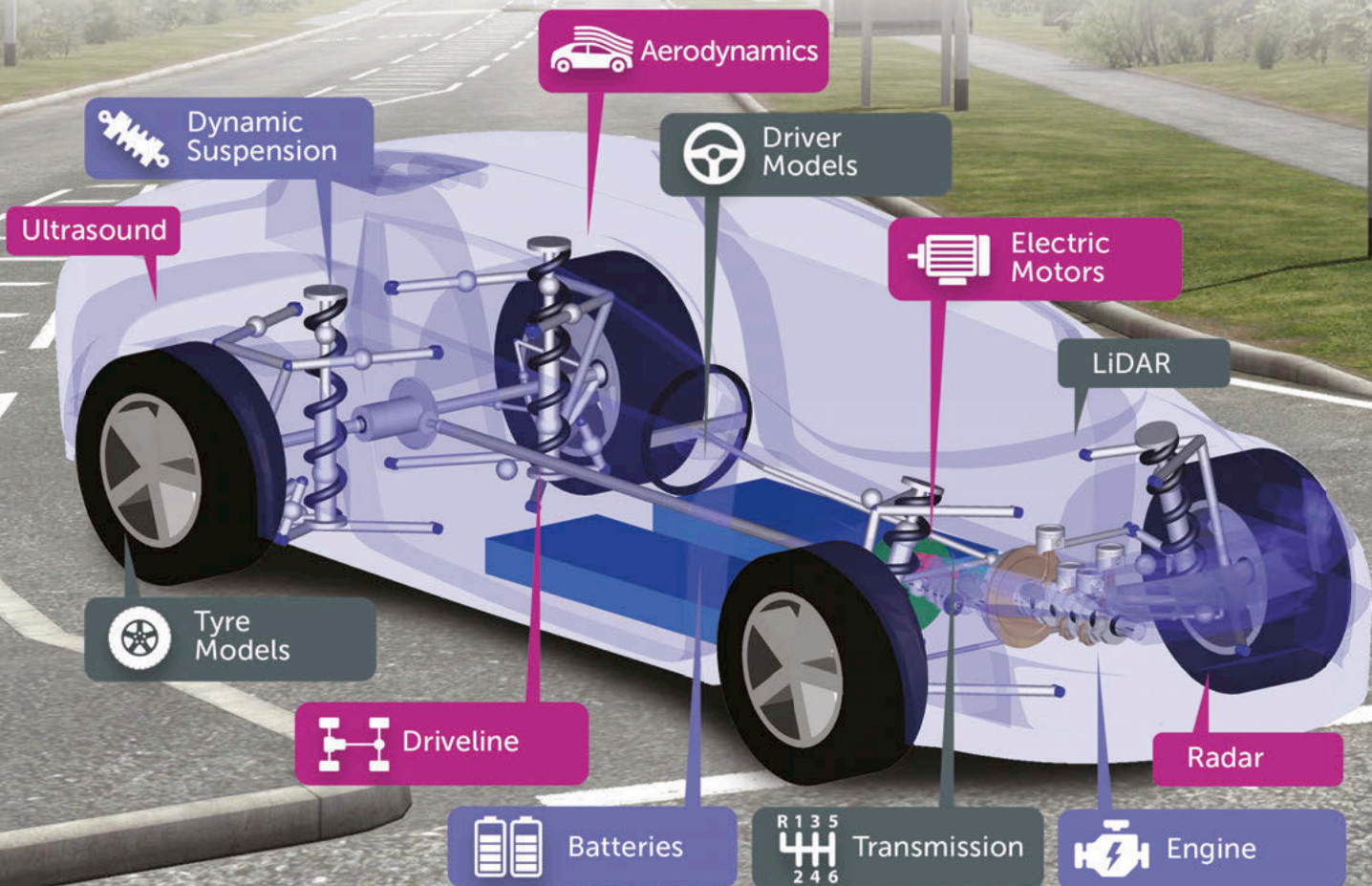


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The Nextrode project aims to revolutionize the way electrodes for lithium-ion batteries are manufactured and improve EV technology for the masses

WORDS: LEON POULTNEY

The Rode to **REVOLUTION**





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1. WMG is set up for collaboration between academia and the public and private sectors to drive innovation in science, technology and engineering

There's good news and there's bad news. "The current processes for lithium-ion battery production have been very heavily optimized, but very empirically. So there isn't really a deep understanding of what's happening in some of the critical stages of the battery manufacturing process," says Professor David Greenwood from WMG, University of Warwick.

This is a problem facing one of the fastest-growing industries on the planet, but luckily Greenwood and his team have just secured funding from a £55m (US\$72m) Faraday Institution grant, which has enlisted five UK-based consortia to conduct application-inspired research over the next four years to better understand lithium-ion battery systems and manufacturing processes.

Demand for energy-dense lithium-ion battery units has sky-rocketed since a global drive to reduce CO₂ emissions dramatically increased production of electric vehicles, but Greenwood feels that critical processes, particularly where manufacturers take the electrochemical materials and mix them to form a slurry, has huge scope for improvement.

"Without wanting to simplify it too much, the current process is a bit like throwing ingredients in a food blender, but mixing it to 500 or 1,000-liter batches. As a result, the formulation of materials that goes into those mixes has been developed via many experiments and a large amount of trial and error," he says. "We don't yet have predictive tools that would allow manufacturers to create an electrode with a specific energy density, power density and mass loading."



"The current process is a bit like throwing ingredients in a food blender"

Professor David Greenwood, WMG, University of Warwick

In addition to this, the team at WMG also understands that the subsequent processes of coating and affixing the microstructure of the electrode is highly empirical, with research proving that arranging the materials in a more structured way can dramatically improve battery performance.

However, the University of Warwick will not be alone in its quest, because Patrick Grant and his team at Oxford University will be lead partners in the research and will specifically look at novel processes that Greenwood feels could replace the more haphazard ones we use today. This research will include 3D structuring of the electrodes for improved performance and energy density.

Sheffield University also forms a part of the consortium and will research the mixing process itself, using computational fluid dynamics and various statistical processes to understand how the particles in the mix end up where they do. Birmingham University will, according to Greenwood, research the electrode material and how manufacturers might one day be able to get the particles to "self structure" in a specific way. The University of Southampton and University College London will also have vital roles to play.

"There are two primary directions for the project: one is to really deeply understand today's processes, while the other is about innovating for the future," says Greenwood.

"Clearly there needs to be a lead on a project of this scale, but all of the partners will need to interact in different ways. Oxford will be leading the disruptive front and we will be pushing forward with data measurement, data analysis and the modelling. To achieve this, there will be a deep level of communication between all of the parties involved."

Driven by data

WMG is well placed to carry out this sort of data-driven analysis, because its cutting-edge "battery scale-up" facility mimics the production equipment found in some of the world's largest battery factories.

By applying instrumentation to test equipment, the team can measure, in minute detail, what is happening in every step of the production process. That therefore allows the team to gain a theoretical, as opposed to an empirical, understanding of what is going on in those processes.

"The technique for building batteries essentially derives from technology that was being used by the likes of Sony to make video cassette tapes"

Professor David Greenwood, WMG, University of Warwick

"There is currently a massive race for capacity in lithium-ion battery factories around the world, and the way many achieve that is simply by replicating something that has worked successfully before and then developing it incrementally," says Greenwood.

"As a result, the technique for building batteries today essentially derives from technology that was being used by the likes of Sony to make video cassette tapes. Of course, it has been highly developed since then, but it takes a very brave investor to bet billions of pounds on a completely new manufacturing process, which is why I think we haven't moved the game on since then."

Although the outcome of this research could improve current battery technology, Greenwood believes that the best result would be to make battery technology cheaper. Cost is currently one of the biggest stumbling blocks for customers looking to make the switch to an electric vehicle, but WMG's research would theoretically allow manufacturers to produce batteries at the level of quality they are today, but at a significantly lower cost.

"Clearly, the stage beyond lowering the cost of production is, by arranging materials in a different way, to ensure the energy density of the battery is much higher. This would result in an increased range for the vehicle and improved performance, improving the product offering to the customer," he adds.

A race worth winning

Although EV manufacturers will be keeping a close eye on WMG's results, it is the Tier 1 suppliers that will likely benefit most from the research. The UK Battery Industrialization Centre is a close partner in the program and Greenwood says it has already shared a lot of data about the lines it has installed. Similarly, QinetiQ has been a close supporter and the

WMG is also looking to work alongside Nissan's former battery provider, AESC.

"Although the OEMs clearly want to know how cheaply we can make the technology and how fast we can pull it off, it is highly unlikely they will be the immediate users. We see the likes of Samsung, LG or Panasonic actually implementing the findings and suggestions from the program," Greenwood explains.

Those Tier 1 suppliers excited by the prospect might have to be patient, because the initial program is predicted to run for four to five years. However, Greenwood points out that part of the Faraday Institution's role is to steer the program in much the same way as an industrial research project, attracting interest and further funding from those parties that could benefit the most.

"This project was put together very much around an industrial need, not just an academic curiosity," Greenwood says.

"The price, the quality and the energy density of batteries is determined not just by the materials that they're made from, but also from the manufacturing processes.

"That is particularly the case now because the scale of manufacturing is so huge," he adds. "For example, a Tesla Gigafactory will produce 20 cells a second and an average technical coating line will be working through 90 meters of material a minute. These are these are very high-speed processes that have to be operating with extreme levels of precision and control. We want be able to optimize these heavily or disrupt the current methods of manufacturing so we approach it in a completely radical way in the future." ◯

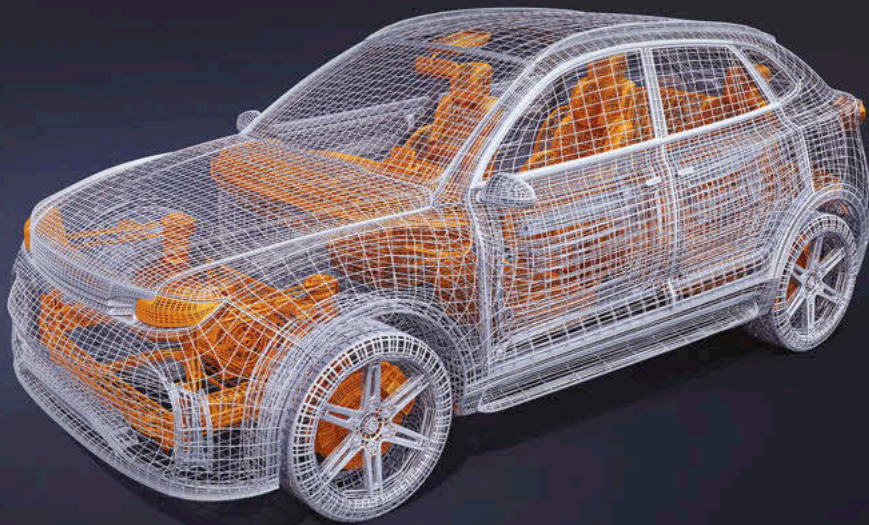
2. WMG is fully equipped to develop, prototype and test lithium-ion solutions. Its cutting-edge facility mimics the world's largest battery factories



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NEW HO



With two all-electric concepts at this the 2019 Tokyo Motor Show, Nissan's chief product specialist for EV and EV concepts, Makoto Fukuda, explains why he is excited for an alternatively-fuelled future

WORDS: **LEON POULTNEY**

ORIZONS



1. Nissan's Ariya concept showcases the brand's ambition to move into the electric SUV market

2. While still a concept, it is believed production versions are imminent



It can be lonely at the top. With more than 400,000 Leaf sales globally, Nissan stands head and shoulders above any other mainstream manufacturer when it comes to selling electric transportation for the masses. Only Tesla can truly compete.

But the Japanese marque knows that leading the way is tough, and one criticism levelled at the company has been the pace at which it has spotted key market trends and innovated. So far, there is still just one non-commercial pure EV in the brand's line-up, while a distinct lack of a SUV body style has seen customers look towards new models from the likes of Kia, Hyundai, BMW and beyond.

On top of this, rival manufacturers have been busying themselves with hybrid options that bridge the gap between pure battery power and the internal combustion engine, supposedly easing the customer towards a plug-in existence.

"We established the idea of Nissan Intelligent Mobility, which incorporates electric mobility and the latest assistance systems, but I think there is still some confusion over exactly what Nissan means by this," says Makoto Fukuda, Nissan chief product specialist for EV and EV concepts.

"There is a thought that by simply installing an electric motor equates to intelligent power, but we don't see this as the case. At Nissan, we strongly believe that the wheels should be



"We strongly believe that the wheels should be driven by an electric motor, and if we use a gasoline engine it will only be used to recharge the batteries"

driven by an electric motor, and if we use a gasoline engine it will only be used to recharge the batteries. This is the most efficient use of a gasoline engine and proves the most fun to drive. We want to keep the excitement of driving. It is important that a Nissan still represents this," he adds.

More motors

Until now, Fukuda's words could have easily been met with some scepticism, but sat behind him during our interview is the marque's

shimmering new Ariya concept, which wowed crowds at the 2019 Tokyo Motor Show thanks to its bold SUV styling and promise of dual-motor electric performance.

"We are on the cusp of a huge leap in performance for Nissan vehicles," says Fukuda, as he walks around the imposing concept. Despite its design-led showcar flourishes, the concept is believed to be very close to a production version.

"Two electric motors give us a big advantage in body control and traction to the wheels. Our



3

early research shows that we have been able to achieve huge gains in cornering ability and acceleration to deliver a really high performance driving experience,” says Fukuda.

The research in question sees a next-generation Leaf e+ test car equipped with front and rear high-power EM57 electric motors, integrated with Nissan-developed chassis control technology. This separate motor system generates 227kW of maximum output and 680Nm of maximum torque. This mighty output is kept in check by the ultra-high-precision motor control provided by Nissan’s advanced EV technology, which offers highly responsive, yet smooth acceleration.

But rather than simply make the new technology about outright performance, Nissan’s engineers have been working hard to increase ride comfort by reducing the amount of pitch and dive associated with heavy regenerative braking systems. To do this, Nissan adds regenerative rear motor braking to the standard front motor regenerative braking to balance it out.

“Of course, the customers are going to benefit from the boost in performance with something like our Ariya concept, but we also wanted to ensure it can also offer added stability across various surfaces,” Fukuda says. “We don’t look to the Middle East or really tricky desert conditions, but we expect a majority of the customers would ski or want



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to drive up a slippery mountain pass. We can provide the best in class performance, compared to an ICE, with EV all-wheel-drive, thanks to the precise control over each axle.”

Power to the masses

Nissan has committed to bolster its EV line-up heavily over the coming years and its e-Power technology, which has helped to make the Nissan Note Japan’s best-selling registered car, is set to enter European markets during the course of 2020.

At that time, sales of electrified Nissan vehicles will increase five-fold, and by the end of the year will be double the market average. As a result, Fukuda claims the company is

3. One of two new EV concepts revealed, Nissan is to increase its electrified line-up five-fold by 2021

4. Nissan is focusing efforts on making battery technology as cheap and accessible as possible



5

focusing its efforts on battery-powered electrification, rather than investigating other alternative propulsions systems, such as hydrogen fuel cell technology.

"We have researched fuel cell in the past as part of a collaboration with other OEMs, but we had to shift research focus on to EV technology," he says. "Resources are limited, so we had to focus on one area and we decided to ensure our EV technology was the best it could be."

He also believes that the company's focus should be on making battery technology as cheap and accessible as possible, while ensuring charging times are kept to a minimum. The race for larger batteries and the longest range isn't one Fukuda believes Nissan should compete in.

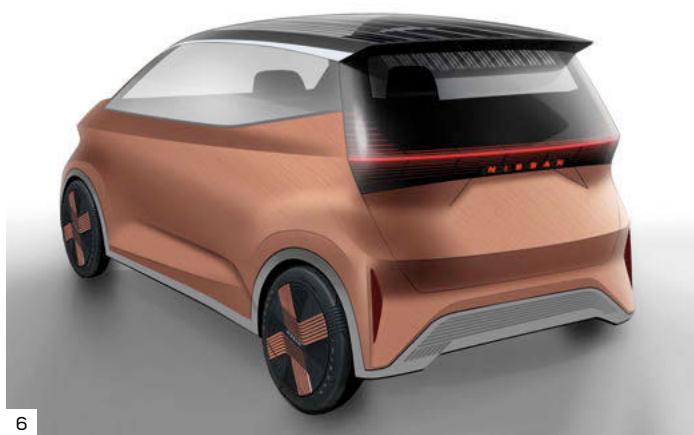
"We should reach a point where battery size is sufficient for most use cases. If customers need an improved range and larger battery packs, this gets expensive and it is a bad cycle to get into," Fukuda explains. "We feel that those longer journeys that require maximum range will typically only be required once or twice a week, and if we can get charging times down to five or ten minutes, we feel the customer will happily accept that, if the overall price is kept to a minimum."

In keeping with delivering electric motoring to the masses, Nissan is also racing ahead with its latest autonomous driving technology and advanced safety function, Pro Pilot 2.0. The ADAS, which will appear in the Japan-only Nissan Skyline, will allow hands-off driving in single-lane situations.

Drivers will be able to pass slower moving traffic with a flick of the indicator stalk and branch off the motorway with ease, only taking back control of the wheel when the system indicates to do so.

The advanced system is only made possible thanks to a plethora of cameras and sensors around the vehicle, 3D high-definition map

"We have researched fuel cell in the past as part of a collaboration with other OEMs, but we had to shift research focus on to EV technology"



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5. The combination of electric power and intelligent driving assistance systems aims to reduce both emissions and accidents

6. At the 2019 Tokyo Motor show, Nissan also revealed an all-electric concept of a Kei car, called the IMk

data and a driver monitoring system inside the car, which continually confirms that the driver's attention is on the road ahead.

A close working relationship with its suppliers means Nissan has been able to reduce the cost of the required technology, potentially making it available to cars in a variety of segments in the near future.

Second coming

Sitting next to the Ariya concept at the Tokyo Motor Show was the equally chic IMk Concept – Nissan's vision of an advanced electric, compact commuter, Kei car that it hopes will improve the reputation of a market segment that has typically been related to poor build quality and performance.

"Our new electric platform has allowed us to investigate a wide range of body styles and we

think the IMk concept has got the potential to be a complete game changer for the Kei car market," Fukuda says.

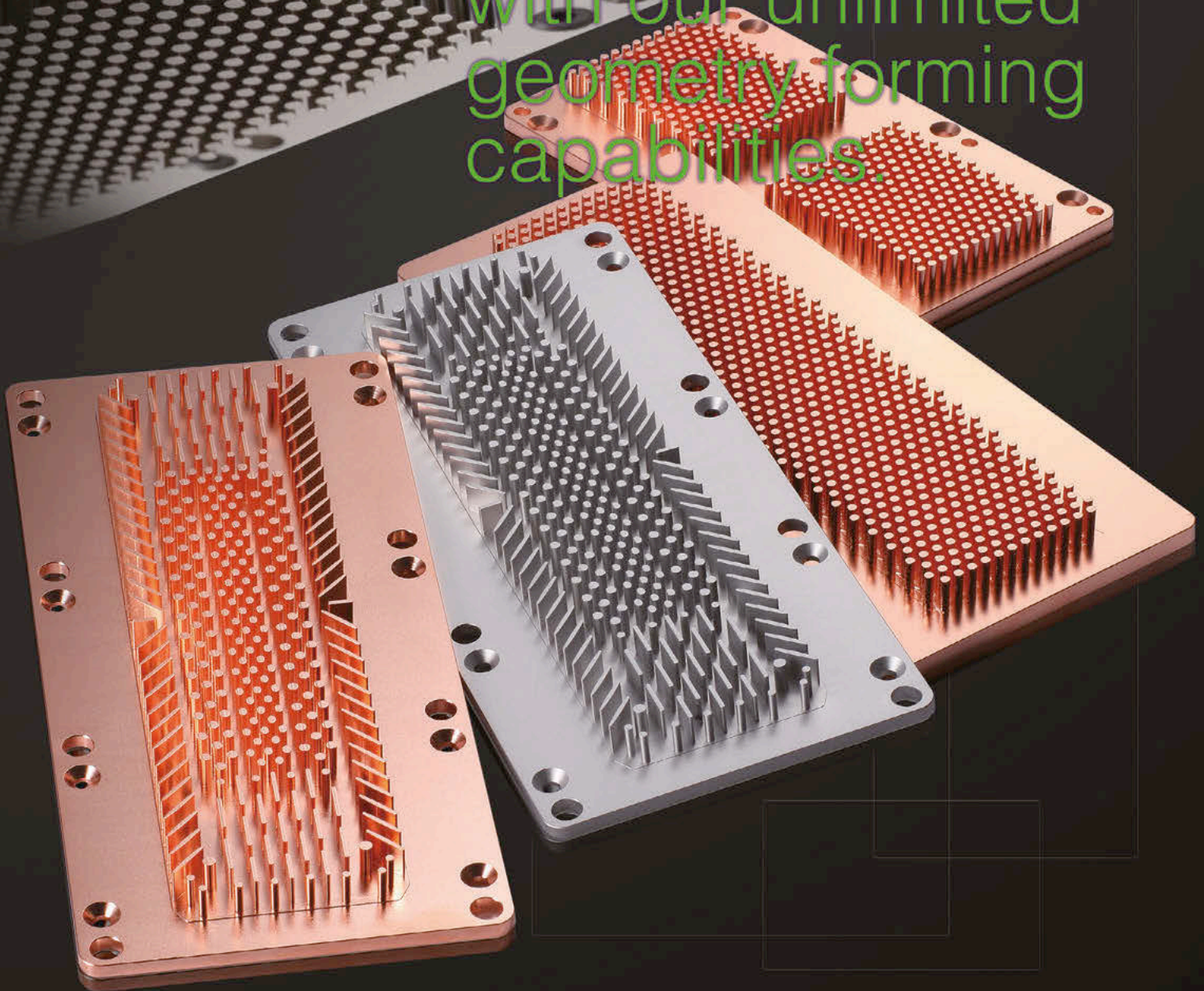
"That concept not only showcases the performance potential with a new EV powertrain and platform, but also the benefits of the built-in active and passive safety systems," he adds.

The Tokyo Motor Show may have been the perfect platform to showcase two new concepts, but read between the lines and it hinted at much more. This was a clear statement of Nissan's dedication to electric propulsion systems.

It may have taken the industry leaders a while to return with another smash hit, but the coming years look set to be packed with EVs that the marque hopes will keep it at the top of the charts. 



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Ion & Steel

Researchers at the University of Sheffield are developing the next generation of lithium-ion batteries to transform the performance and range of electric vehicles

WORDS: **FRANK MILLARD**

The University of Sheffield is serious about electric vehicles. So serious that its Transport Services department supplies electric vehicles for the use of staff and students available for hire and charged from 95% renewable sources on campus. Sustainability is in the DNA of research at the university, so its energy storage research fits this model.

The Steel City university's Department of Chemical and Biological Engineering, for example, is a cutting-edge research facility, and one of its aims is to achieve sustainability by developing and deploying "novel technologies for low-energy consumption with high selectivity for biological, chemical and physicochemical transformations that valorize biomass and waste feedstocks". Reducing emissions is one thing, but to achieve those reductions, batteries need refinements to improve the performance and range of EVs.

The department announced recently that it was receiving funding from the Faraday Institute as part of a research project called the FutureCat project in collaboration with Cambridge, Oxford, and Lancaster universities, UCL, the Science and Technology Facilities Council and 11 industry partners. The team is also looking at reducing dependency on cobalt by improved cathode design.

The award of £11m (US\$14m) is enabling researchers led by Professor Serena Corr, chair in functional nanomaterials at Sheffield University, in the development of lithium-ion batteries with longer lifespans and increased energy density, and in particular a co-ordinated approach to cathode chemistry design and development. The aim is to deliver cathodes that hold more charge, are better suited to withstand prolonged cycling and promote ion mobility, to help increase the range and acceleration of electric vehicles.

The Faraday Institution itself was founded only recently, in 2017, and now has an active programme of research across nine consortium projects. The Faraday Institution is an independent body for electrochemical energy storage research and skills development, based in the UK.

The FutureCat project – or the Faraday Institution Future Cathode project, to be precise – began on October 1



and will enable a consortium of researchers across five academic institutions to pursue cutting-edge research. Corr reveals she and her team will also be working closely with external partners, the National Physical Laboratory and the ISIS Neutron and Muon facility, to establish the improved performance of the department's fully characterized new materials against the current industry standards. "We have very strong industry engagement and are joined by nine industry partners to ensure that the discoveries we make in FutureCat lead to economic and technological impact. Crucially, our project will also train the next generation of scientists and engineers," Corr states.

FutureCat will unlock the chemistry and manufacturing principles needed to roll out the next generation of lithium-ion batteries with enhanced cyclability, higher energy density and, crucially, using ethically sourced, abundant materials, claims the professor. "The University of Sheffield is the lead institution in this work, with expertise that spans materials design to manufacture, as well as battery cell fabrication and testing, we bring together collaborators from across the UK to deliver advancements in electrode discovery, development, longevity and resilience."

The researchers have been working on cathode developments for many years now. In particular, they have been establishing new synthetic routes to high-performance materials for use in lithium and sodium ion batteries, as well as all solid-state batteries. "As part of existing research

"We will be examining what earth abundant elements can reproduce the performance effects of cobalt"

Professor Serena Corr, chair in functional nanomaterials, Sheffield University



1. Researchers working on cathode advancements for use in lithium and sodium ion batteries

programs, we have been expanding our understanding of degradation processes occurring in lithium-ion batteries and developing strategies to mitigate those degradation processes, for example through the use of protective coatings on the surface of cathode materials. The FutureCat project builds on this expertise to establish new families of battery cathode materials, some based on known chemistries where we have the knowledge and know-how to push the boundaries of existing materials of interest to industry, and others based on the discovery of new materials where we are targeting low/zero cobalt chemistries to reduce cell manufacturers' dependency on cobalt."





Drive for sustainability

The chemistry behind the batteries that drive electric vehicles is comprised of limited resources confined to certain locations around the globe, but technology is progressing to restrict this dependency. The Sheffield university research is part of this process of ensuring energy security and ethical sourcing of materials.

“There are a number of possible approaches that we will be examining to remove the reliance on cobalt in future lithium-ion cathode materials,” says Corr. “For example, for currently applied layered cathodes, we will be examining what earth abundant elements can reproduce the performance effects of cobalt. We will achieve this through a coordinated computational and experimental design approach. High capacity can also be achieved through cation-plus-anion redox-activity and here we will employ manganese-rich cathodes, again reducing the need for cobalt. The key to the success of a material will be a high capacity, whilst at the same time providing structural stability, and the team we have assembled has the expertise to design high capacity materials with targeted crystal structures.”

The FutureCat research program is agile and integrated to harness the resources afforded by an interdisciplinary team. “Our

work starts at the atomic level, choosing the elements and crystal structures most likely to yield high performance. The materials are synthesized and formulated into batteries using bespoke processing methods targeted at producing ideal nano and microstructures,” says Corr.

“Batteries are tested using standard protocols, but we’re also developing new testing methods that probe the stability of sensitive interfaces so that we can predict problems long before a battery fails in cycling. The best materials progress to scale-up, where we develop synthetic and manufacturing strategies to produce commercial quantities of cathode. Supported by multi-scale modelling, a main objective of our work is to develop a theoretical framework for screening materials and predicting performance based on chemistry and structure. This knowledge discovery represents a step-change for the battery industry.”

Technical feasibility

The project is already well underway, performed by appropriately skilled and experienced academics, and taking place in a pre-existing materials and energy-storage technology research environment. This kind of university research is vital for an industry conscious of establishing the technology needed to assuage lingering public anxieties about range and performance, so accelerating public

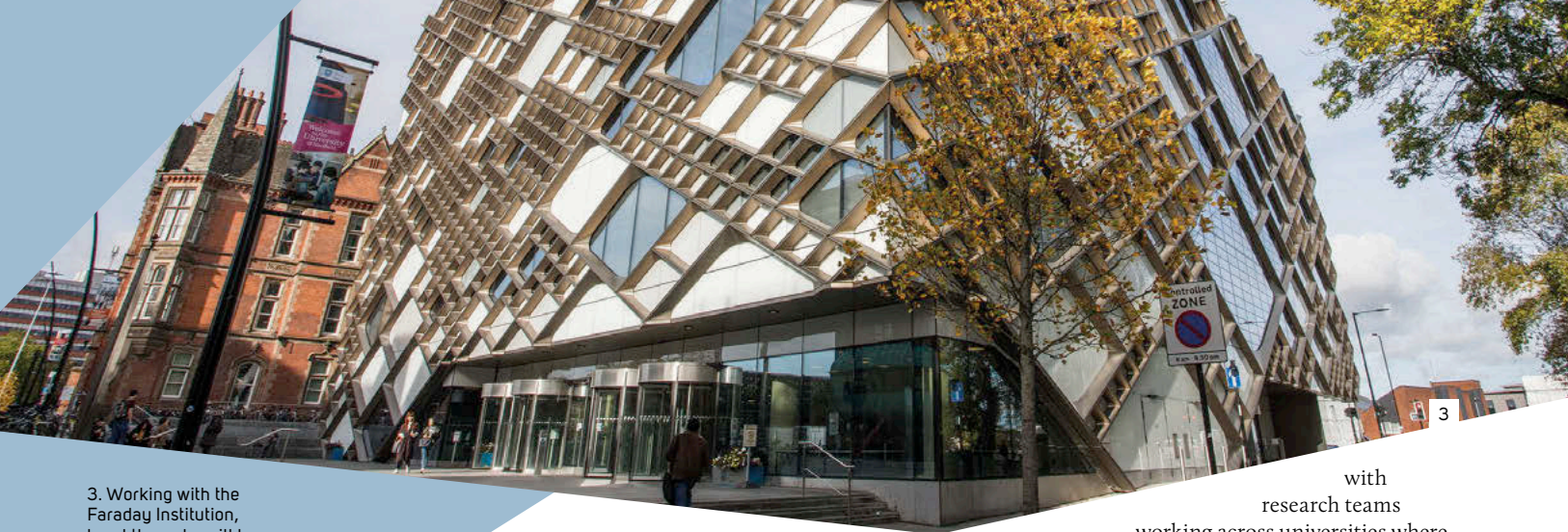
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2. Sheffield University has been awarded £11m (US\$14m) for its work



"The key to the success of a material will be a high capacity, whilst at the same time providing structural stability"

Professor Serena Corr,
chair in functional nanomaterials,
Sheffield University



3. Working with the Faraday Institution, breakthroughs will be fast-tracked to industry

adoption of electric vehicles that are not only environmentally friendly but comprise the best and most suitable public and private transportation on the roads. Consequently, adoption becomes a positive choice, rather than a legislated enforcement.

"Our first new materials have already been synthesized and are undergoing characterization. The rich expertise of our members translates to an increasingly streamlined materials-performance design cycle. Within our first quarter, we will be in a position to propose better performing materials that we can fast-track to scale-up. We anticipate a long-term dialogue with materials and battery manufacturers that optimizes technical performance given commercial constraints, such as management of the supply chain."

Other institutions

The department will be working closely with the Faraday Institution and its panel of experts to ensure maximum impact and uptake of new discoveries made by FutureCat researchers, says the team lead. "Our consortium is a close and collaborative partnership between universities. Our approach is highly integrated,

with research teams working across universities where they can access leading expertise and state-of-the-art facilities to enable cutting-edge research. Our efforts will also be guided by our partnerships with the industry to ensure our efforts are closely aligned and to fast-track our discoveries to scale-up.

"FutureCat deploys a hybridized management strategy that combines the agility of academic work with the goal-focussed drive of agile management," says Corr. "Feedback is key to connecting our diverse members and identifying critical connections. Our research teams have regular meetings to share results, collaborate effectively and ensure our project is delivering across our milestone goals. Facilities for synthesis, characterization and testing exist across our institutions and our partnership with NPL ensures that robust testing criteria will be applied to emerging cathode technologies."

Another team, led by the department's Dr Denis Cumming, is also partnering in two of four other Faraday research projects, including a University of Oxford-led project called Nextrode, aiming at a new generation of smart, high-performance electrode manufacturing, to assist in extending the range and increasing the performance of EVs. These researchers from the University of Sheffield are also collaborating in a University of St Andrews-led project, Nexgenna, to speed up the development of sodium-ion battery technology. There's no question that the Steel City is playing a big role in shaping the battery technology of the future. 

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Battery
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Battery
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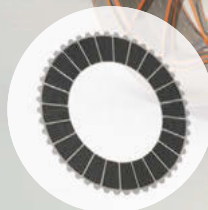
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Sintered
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Hair-Pin Stator
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Production Lines

Electric and Hybrid Vehicle Technology Expo Europe and The Battery Show 28-30 April, 2020, Stuttgart, Germany

Discover the future

Electric & Hybrid Vehicle Technology Expo Europe brings the leading experts and suppliers in the EV industry together again for its biggest show ever

The growth of the Electric & Hybrid Vehicle Technology Expo Europe (EVT) has been phenomenal. "It's actually been amazing. We've been a part of this since its inception, and we watched it grow from the 50 people displaying [merchandise] all the way up to this year, where they have sold out," Brad Gibson, global business director at Lord, exclaims after attending the 2019 trade fair.

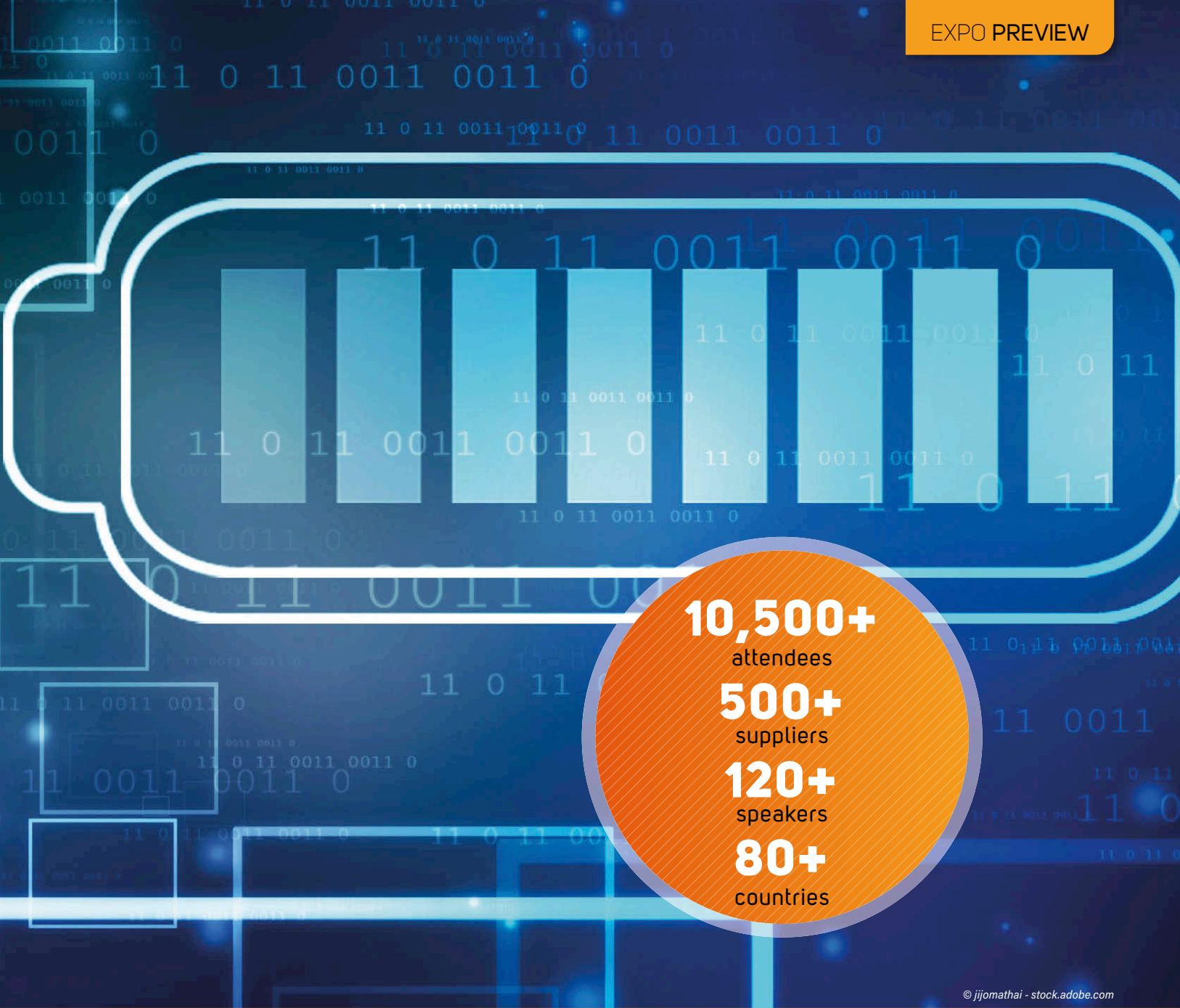
The fair was a great success with nearly 11,000 attendees, over 600 delegates to the event's educational conference, and participants of all types from 82 countries. The event's managers expect the 2020 edition held in Stuttgart, Germany, to be even better. They

project it will attract over 12,500 attendees and more than twice as many as the fair's first edition in 2017. The attendees come to meet the show's 610 exhibitors, up from 498 in 2019.

The fair's growth mirrors that of the e-mobility market. "A global shift in consumer spending habits, married to a growing sense of environmental responsibility, especially among younger drivers, is sending EVs mainstream. Research shows millennial and Gen Z buyers are more environmentally conscious than their predecessors – a mindset which makes an electric car with zero tailpipe emissions seem increasingly attractive," says *Wired* magazine. In the words of Jim Greig, Lord's global director of business development and sales for

electrification solutions: "It's a bright future for the EV market, I can't wait to see what it holds."

This growth is especially strong in Europe. Economic forecasting company BloombergNEF expects European sales of electric and hybrid passenger cars to grow 35% in the first nine months of 2020, a faster rate than China or North America. During the 2020s, Europe will pull ahead of the United States as the second largest market (after China) for electric passenger vehicles. In December, European Commission president Ursula Von der Leyen announced the European Union's initiative to reach climate neutrality, which is to produce only as much as greenhouse gas as the environment can safely absorb, by 2050.



10,500+

attendees

500+

suppliers

120+

speakers

80+

countries

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Networking event

The market's rise has helped EVT, but the show has other advantages as well. It's not just a typical trade fair. It's "the point where the industry comes together now," says Eugenio Toccalino, global strategic marketing vice president for transportation and advance polymers at DuPont. This is further supported by Michael Grondowski, Mitsubishi Electric industrial automation sales solution expert, who claims "it's the best place to have talks with the whole industry."

Some of those talks spark new relationships. "EVT is a great experience, great for networking and collaborating with key partners in the industry," says Jared Kearby, an

analyst at Power Technology Research. Peter Steinbrueck, a Benteler Automotive development engineer, agrees: "I've never experienced such e-mobility know-how and so many networking opportunities in one place."

Of course, many visitors come to do business. "I talked to our people at the stand who said they didn't have a single minute to breathe. They've been busy at all times with customers, partners, and sealing new collaborations," reveals Toccalino of DuPont, who exhibited at the fair in 2019. "It's the unmissable event in the industry for us," he adds, with DuPont exhibiting again in 2020.

The typical attendee at the fair is a European engineer (the show attracts more people from

engineering than any other field) who works in manufacturing, raw materials, or the supply chain. Meanwhile exhibitors range from startups to industry giants such as 3M Deutschland, Trumpf, and Voltabox.

Looking ahead to the future, a recent survey from business information company Research and Markets predicts that the e-mobility market will keep rising, with a compound annual growth rate of 21.6% from 2019 to 2025.

"There's a lot of investment going on around the world. We're very happy to be here and be a part of this," says Lord's Gibson.

For more information about the event, visit:
www.evtechexpo.eu



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I've never experienced such e-mobility know-how
and so many networking opportunities in one place.

— Peter Steinbrueck, Development Engineer, Benteler Automotive

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Key topics for 2020 include:

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- Latest Developments in Electric Motor Design
- Improving Efficiency in EV Transmission & Powertrain
- Global Electric and Hybrid Vehicle Forecasts & Developments



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Voices of the industry

One of EVT's biggest attractions is its educational conference, which features keynote speakers from top OEMs, pre-conference workshops, and six full tracks of education covering topics crucial to every stage of the advanced battery supply chain. "It's a very solid baseline on what's next in terms of technology implementations around EV," comments Andrea Dolfi, global technology manager for engine fluids and motorsport at Petronas Lubricants Italy.

Sessions including Latest Developments in Electric Motor Design, Electrification of the

Off-Road Vehicle Market, and The Future of Electric Vehicles in a Rapidly Changing Industry uncover the newest breakthroughs. "What is good about this conference is you have a lot of experts – technical experts, not the experts in LinkedIn and handshaking, but really those guys who have the core knowledge," says Marcin Seredynski, head of research and innovation at Volvo's e-bus competence center.

For a full conference schedule, visit the EVT website: www.evtechexpo.eu



MAHLE

An international auto-parts maker based in Stuttgart, Mahle celebrate its 100th anniversary in 2020. It claims half of all automobiles produced worldwide contain Mahle components with its systems solutions in every kind of vehicle, from e-scooters and machinery to commercial vehicles and passenger cars. The company produces high-efficiency drive systems and power electronics for electric powertrains. Its products include traction inverters, onboard chargers, EMC (electromagnetic compatibility) battery filters, DC-to-DC isolated voltage converters, fuel-cell monitors, motor and heater controllers, and electronics for diesel systems. The company has even developed its own concept car, Mahle Efficient Electric Transport (MEET), a 48-volt vehicle for urban mobility.



LECLANCHÉ

Headquartered in Switzerland, Leclanché is a leading provider of high-quality energy storage solutions. The company is at the heart of the electrification of marine, rail, and commercial vehicles. At EVT, Leclanché will present products for more efficient electric transportation as well as solutions for enhanced battery safety. Leclanché's history and heritage is rooted in over 100 years of battery and energy storage innovation. Its own European cell-manufacturing capabilities and module-and-pack assembly combine German engineering and Swiss precision and quality. The company takes pride in being a total energy system solutions provider, capable of delivering fully self-contained energy storage systems suitable for all transport sector applications.



VALEO

Valeo provides smart thermal management for electrified vehicles. The company designs cooling solutions to make the most of a car battery's performance while maintaining passenger comfort via dynamic control of the car's air-conditioning system. Valeo also improves vehicle performance with aerodynamic solutions such as active grille shutters at the front end to reduce drag coefficient by 9%, plus light structural solutions such as composite battery casings (with no compromise on mechanical resistance) that offer up to 30% weight reduction. At the expo, Valeo will demonstrate battery cooling systems, an optimized heat pump system that can extend an electric vehicle's range by up to 30% in winter, and composite battery casings with integrated battery coolers.

KEY DATES

Pre-conference workshops
Monday, April 27

Keynotes

Tuesday, April 28 – Thursday,
April 30

Conference tracks

Tuesday, April 28 – Thursday,
April 30

**ELAPHE PROPULSION**

Elaphe provides in-wheel powertrain platform solutions, an enabling technology for the new era of automotive innovation. Patented designs for in-wheel propulsion enable Elaphe products to be tailored for specific ranges of torque and power to fit most vehicle configurations. The company's motors, power electronics, intelligent multiple-motor propulsion control, and other forms of propulsion technology have been proven in the world's highest-performance in-wheel-powered applications. At EVT, Elaphe will showcase its entire updated ecosystem of powertrain solutions, from the newest generation of the Elaphe PCU – an ASIL-D-ready, ISO26262-capable multi-motor control unit – to the most powerful in-wheel motor with the highest specific torque on the market, the Elaphe L1500.

**TE CONNECTIVITY**

At EVT, TE Connectivity – a world leader in connectivity and sensors – will showcase the latest innovations from its end-to-end power distribution, battery control, and connectivity portfolio. Visitors to Booth #940 at the fair will experience new product demonstrations, take part in a program of TechTalks, and interact with leading TE experts in hybrid and electric mobility technology.

"The breadth of product and technology innovation we are exhibiting at this year's show will surely excite customers and other visitors, as they realize we offer a complete solution for end-to-end power distribution, battery control and connectivity," describes Luis Puras, senior product manager for hybrid and electric mobility solutions at TE Connectivity.





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MAHLE

“ The thing that brings us
back is the combination
of both decision makers,
engineers and the
scientists that you get
to meet face-to-face. ”

— Jeff Norris
CEO
Paraclete Energy

For more information visit www.evtechexpo.eu

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Innovation in motion

WORDS: **KARL VADASZFFY**

With the drive toward a more electric future, greater investment is going into developing technologies that will ensure we create a cleaner planet.

The strategic focus of Miba eMobility, a solution provider with deep application know-how and process knowledge that goes right down to the raw material, is the development, production, and supply of components for electric and hybrid vehicles.

Its products for batteries have already been successfully introduced to the market. These include innovative battery cooling and thermal management solutions and safety components.

Miba eMobility is working with its customers to deliver innovative products and solutions in the global shift from combustion engines to electrical powertrains. Stefan Gaigg, business unit leader battery, comments, "Thermal management in electric car batteries is critical to determine range and longevity, and is also the key to successful fast charging."

To fulfill these demands, he says a major industry trend is the move toward liquid cooling. He reveals that the main challenge here is in creating an efficient thermal connection between the battery modules or cells and the heat sink. "State-of-the-art heat sinks are thermally connected to the battery using thermal interface material. Such thermal interface materials, also known as gap fillers, can be added in the form of pastes or pads. In the end, besides weighing up to several kilograms, the heat sink and gap fillers also result in considerable expense."

Therefore, Miba's flexible heat exchanger, FLEXcooler, combines interesting material properties for a completely new heat exchanger design for liquid-based cooling. Its flexible polymer material forms a tight thermal contact with the battery cell housing. "A key advantage

1. Miba and Voltlabor have created a battery module with a closed cooling system that enables a homogeneous temperature distribution throughout the entire pack



2. Miba's FLEXcooler technology is a battery cooling system that is adaptable to a broad range of geometries

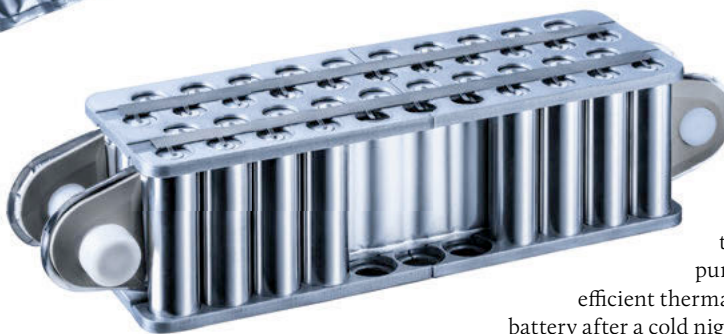
of this heat exchanger," says Gaigg, "is that the thermal contact is formed even without thermal interface materials, which must be used with conventional heat exchangers." The flexible heat exchanger is electrically non-conductive, with a dielectric strength above 5kV, which provides an additional level of electrical safety.

Flexibility of materials, he suggests, enables additional benefits such as compensation of manufacturing tolerances and enabling cooling in gaps as small as 1mm. Larger gaps, up to 6mm, are also possible.

The flexible heat exchanger is highly durable, able to withstand 250,000 pressure pulses from 0.1 to 2.5 bar without any damage. "This is far above the operating pressure," explains Gaigg. "Already, pressures of 0.5 bar press the heat exchanger tightly against the housing of battery cells. The resulting tight thermal contact between heat exchanger and battery cells with typical heat transfer coefficients of $\sim 1000\text{W/m}^2\text{K}$ provides efficient cooling, demonstrated for example by the uniform temperature of the chilled macro cell that is built of cylindrical cells."

The flexible heat exchanger can be operated at temperatures ranging from -30°C to $+60^\circ\text{C}$ (-22°F to 140°F). It can also be custom fit to almost any battery design, ranging from prismatic to pouch and cylindrical cells and format. Sizes of 2,000mm x 1,400mm are possible.

Hausjell reveals that work is already underway on the company's next generation of flexible heat exchangers: iFLEXcooler will be intelligent and flexible, able to sense the temperature at the interface between the heat exchanger and battery. "The heat exchanger can even be equipped with heating," he explains. "An advantage of this is that heat is generated right where it is needed – at the interface between the battery cell and heat exchanger at powers of several $1,000\text{W/m}^2$." This, he says,



reduces energy loss due to the heating of the coolant or coolant pump, which provides efficient thermal management of the battery after a cold night.

Looking ahead to the future

The recyclability of battery packs will become even more important. Despite the tight thermal contact of the flexible heat exchanger, the contact is mechanically reversible, enabling easy disassembly of the heat exchanger and battery. "Saving the thermal interface materials will reduce the product's environmental impact and it will also reduce the number of resources used."

"Together with Voltlabor, we have built a battery module that demonstrates all these advantages. It is highly versatile due to the modular macro cell, and is suitable for different module and pack sizes while being optimized for automated assembly."

A further key issue in the future will be increasing power density. The FLEXcooler will contribute to this twofold. First, by reducing the space required for cooling, and second, by providing a higher efficiency in cooling, which may be needed if power density and any resulting power density loss increase. "The trend to fully automated assembly processes will continue," he adds, "and we will support our customers in this with our products that are optimized for automated assembly processes."

Also important is monitoring the state of the battery, in preserving capacity and counteracting damage to it. "With the integration of sensors in the heat exchanger, such monitoring will become possible." Time to market, Gaigg says, will continue to get shorter in what he calls "the global exchange of ideas." And he concludes, "We will continue to prepare for this with highly adaptable production, suitable for different formats and sizes of batteries and heat exchangers." 



"Thermal management in electric car batteries is critical to determine range and longevity"

Stefan Gaigg, business unit leader, battery, Miba



3. Prismatic and cylindrical battery cells can be cooled to prevent power loss

A safe future

As vehicle complexity increases, the need for more physical testing can be negated by the use of careful and efficient modelling and simulation

WORDS: KARL VADASZFFY

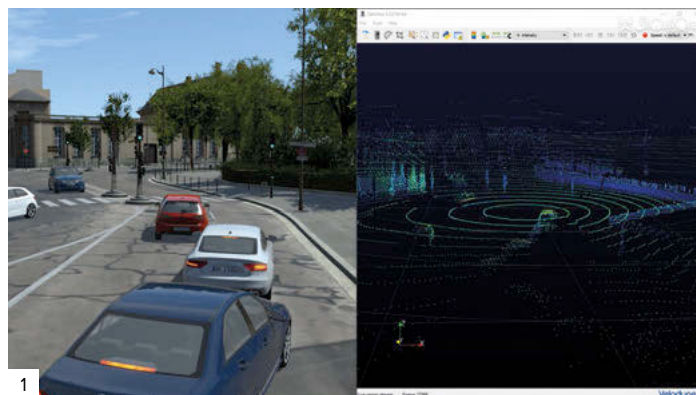
One of the objectives for automotive OEMs over the past decade has been to try to reduce the number of prototypes and the amount of physical testing required. Yet as system complexity has increased, so the number of different types of tests that need to be carried out has risen substantially. Through careful use of simulation, however, it is now possible to use virtual testing to replace many physical tests.

As a developer and distributor of modelling and simulation tools for systems engineers, Claytex has been working on the development of tools and methods to enable the use of physics based models in virtual test environments for more than 20 years.

The company uses DYMOLA to model all the vehicle systems, from the battery, power electronics and motors to the mechanics of the suspension and fluids in the cooling systems. Mike Dempsey, the company's founder and MD, explains, "We take the physics models and embed them in another simulation tool, rFpro, which enables users to drive vehicles around different locations and scenarios. This can be used as a driver-in-the-loop or autonomous AI system-in-the-loop to see how the complete vehicle – its sensors, control systems and physics – work and operate together."

1. Claytex has developed an rFpro simulation with Lidar sensor model for testing autonomous vehicles

2. Simulating an entire autonomous vehicle allows Claytex to test for scenarios such as pedestrians stepping into the road



Using models that are based on physics is particularly important, Dempsey says, because they mean "we are using predictive models rather than models that are characterized from data that's been already measured, so we can do a lot more simulation up front, early in the design cycle, to work out if the system is going to do what is expected and required."

As the complexity of modern vehicles continues to increase, he suggests that "physical testing alone is not enough because there are so many variables that can't be controlled in the real world, which makes it hard to repeatedly do the same test." The opposite is true with simulation, which

"gives users complete control over everything, making it possible to repeat the same test time and again while exploring how changes made to the system will improve the response," Dempsey says.

The introduction of simulation has not been responsible for reducing the amount of physical testing that is needed, but Dempsey says it prevents far more testing from being required. "In reality, what simulation means is that you're not necessarily having to increase the level of testing, despite the extra complexity of everything that is being put into vehicles."

Hot topic

Developing electric vehicles brought along new challenges. In the early days of EV development, these centered around thermal management and how to manage the temperatures not only of the electric systems, but also in keeping occupants comfortable, Dempsey says.

"Without an internal combustion engine producing lots of waste heat that can be harnessed, we've had to explore heat pump technologies, looking at how to capture the available heat and transfer it efficiently around the system so that we can optimize the energy usage," he adds. "Using our solutions, we can objectively measure human comfort in the vehicle cabin and adjust the behavior of the HVAC system to keep the occupants feeling comfortable, while keeping all the systems in the car within their preferred operating ranges and minimizing the overall energy usage."





DYMOLA, he argues, is the optimal tool for this as “it has application libraries that cover the different sub-systems and these can be combined together to model the complete vehicle. This includes having objective measurements of human comfort inside the vehicle cabin.”

On the subject of batteries, Dempsey believes that the understanding of how to model them continues to advance. “We’ve seen the models develop from simple equivalent electrical circuits to detailed cell models that include the electrical, thermal and ageing effects,” he says. “The models allow us to characterize at a battery cell level and then scale up to determine how a complete pack will behave.”



"Simulation means you're not necessarily having to increase the level of testing, despite the extra complexity being put into vehicles"

Mike Dempsey, managing director, Claytex

This, he adds, is already very challenging, yet it will need to become “even more complex in the future in order to get a first principles understanding of those systems”.

Claytex has been working on autonomous vehicle projects for a number of years already, Dempsey says. “We were asked to simulate a complete autonomous vehicle, so using rFpro we developed radar, Lidar, ultrasound, and camera sensor models so that we can connect

the complete AI control system and run that inside the virtual environment.

“Our focus moving forward is on how to continue to improve those sensor models, how to obtain better simulations for our cameras to support machine vision applications and how to achieve better physics-based models of radar and Lidar.” As part of this, Claytex is participating in several innovate UK projects, the objectives of which are to define the scenarios for autonomous systems that need

to be tested, how to manage and characterize these and, finally, how to automate the virtual testing in intelligent ways to measure the system performance.

Looking ahead, Dempsey says a major industry initiative is the ACES trend (automated, connected, electrified and shared). “We must constantly evaluate how we can provide better models to simulate increasingly electrified vehicles, and how we can do that in real time while increasing the fidelity of the models we offer. We need to do this while considering how we provide simulation tools that allow us to prove that an autonomous vehicle is safe.”

Physical testing to prove their safety is not enough, he argues. Instead, simulation tools need to support physical testing, but it is only through the use of extensive simulation that we can hope to get the level of test coverage required to prove the safety of autonomous systems. “To do this, we’ve got to determine how to build accurate sensor models and validate that they are correct, the same for the physics of a vehicle. Then we’ve got to develop the tools and techniques for managing potentially millions of test scenarios, while considering how we automate the testing and measure the system performance across that suite of tests.” It’s mighty task, but one that Claytex is on the road to achieving. 



3. The DYMOLA vehicle system layout

4. The DYMOLA modeling platform in action

How cobots are molding the factory of the future

In automotive production, collaborative robots are working with humans to enhance throughput while continuing to harness human ingenuity

► Recent history has seen a trend towards the robotization of the automotive production line, with fast-moving autonomous devices shunting works-in-progress from place to place and modifying them in the absence of human operators. However, even more recent history is seeing this trend take on a new form. Caged-off industrial robots are quickly being replaced by collaborative robots – or ‘cobots’ for short – that work in tandem with humans.

That capacity to interact means collaborative robots such as Omron’s TM Series are a great way for manufacturers to automate repetitive tasks while harnessing the human creativity required to stay flexible. The concept of flexibility is rapidly gaining traction as more companies strive to produce multiple vehicles – including variations of electric and hybrid vehicles – on the same line to adapt seamlessly to market changes.

Collaborative robots are well suited to today’s demands because they are designed to be as simple as possible to program, and many varieties feature extremely intuitive hand-guided teaching mechanisms that even novice operators can pick up easily.

An operator can move the arm to the first location for a particular step, press a button, move it to another location, press the button again, and the robot will memorize the exact trajectory. Various end-effectors can be used for pick-and-place, gluing, soldering and other tasks.

Omron’s TM Series Collaborative Robot uses integrated vision and 3D positioning to achieve an even more advanced toolkit that allows



As manufacturers strive to design production lines that build multiple vehicle models, ranging from gas-powered to hybrid to fully electric, human creativity is needed to design the most efficient layouts and resolve any bottlenecks that arise

it to respond effectively to new requirements as they arise during manufacturing. If a particular line is dedicated to more than one vehicle type, the cobot’s vision system can scan a barcode on an incoming part to determine which vehicle it belongs to and gauge its size and shape to adjust its positioning.

With all the changes occurring in the automotive industry, of which the shift from gas-powered cars to electric ones is a key example, the variety of vehicle types that a given automaker must manage has increased dramatically. This is causing batch sizes in production to shrink, which in turn creates a need for greater production flexibility.

Most robots perform poorly when flexibility is prioritized, but collaborative robots are very well suited to these new requirements.

There is another aspect – they can also take over tasks that are cumbersome and sometimes even dangerous for humans. Collaborative robots such as the Omron TM Series can lower the



strain on plant employees by moving heavy payloads from one location to the next. They can also make the workplace significantly safer by taking over welding tasks that would otherwise put workers in the pathway of extremely hot objects.

Even if a particular job isn't dangerous, it could be repetitive enough to cause injury – or at least



Omron's TM Series Collaborative Robot uses integrated vision and 3D positioning to offer an even more advanced toolkit that allows it to respond effectively to new requirements as they arise during manufacturing

boredom. If a robot can do this task instead, why not improve an employee's job satisfaction by giving it to another entity? The simple-to-use teaching function of Omron's collaborative robot makes it easy to hand over a day's worth of repetitive work, whether it be machine tending, assembly, screwdriving, or dispensing sealing material.

The argument in favor of giving repetitive tasks to a collaborative robot is strengthened by the observation that robots are able to perform them with much greater quality and consistency.

Checking dimensional tolerances is an example of a task in which a cobot significantly improves the outcome. Every part – particularly the power transmission and engine assembly – in a vehicle needs to have specific dimensions, and cobots can make sure all parts are within the desired tolerances.

With a highly adaptable design, cobots can be redeployed to almost any task in almost any workspace

without requiring changes to production layouts. One particular capability that is unique to Omron's cobot is that it can locate parts coming down the line in any orientation. This powerful use of integrated vision eliminates the need for complex, rigid fixtures that confine parts to extremely specific placement.

As manufacturers strive to design production lines that build multiple vehicle models, ranging from gas-powered to hybrid to fully electric, human creativity is needed to design the most efficient layouts and resolve any bottlenecks that may arise.

If a collaborative robot replaces a human worker on a machine-tending task, the operator can focus on more complex activities such as quality inspection or line-change planning and preparation.

Ultimately, the benefits of incorporating collaborative robots into the automotive production line are immense. Operators performing

back-breaking tasks such as lifting heavy parts can now quickly set up a cobot to take these over, and the ability to hand off welding tasks to a cobot is another step towards keeping workers out of danger. Whenever a human touch is needed, the cobot can work safely and seamlessly with an operator to add finesse and consistency.

No longer fenced off like traditional industrial robots are, collaborative robots can quickly learn new tasks on the fly and use integrated vision to respond flexibly to new parts that require new jobs to be done. With the automotive industry trending towards high-mix, low-volume customization to accommodate the needs of customers choosing between electric, hybrid and other options, cobots present a welcome solution to the challenges that arise. ●

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Chasing the sun

The smallest measurable improvements in efficiency can make the difference between winning and losing a solar-powered car race across Australia

► The 3,020km (1,876 mile) Bridgestone World Solar Team Challenge, which took place in October 2019 in Australia, from Darwin to Adelaide, was won this year with an average speed of 86.6km/h (53.8mph), seeing an improvement of 5.4km/h (3.3mph) or 6.6% compared to 2017. This biannual event is the ultimate racing challenge for cars powered entirely by the sun.

The basic design of all cars in the race is similar: an aerodynamic wing shape covered in arrays of photovoltaic panels to convert the sun's light into electric power, which is fed directly to a motor driving the wheels, with any excess stored in a small on-board battery.

To win the World Solar Challenge, the race car must capture as much solar energy as possible and convert the electricity it generates as efficiently as possible into mechanical power delivered to the wheels. At the same time, it must keep energy losses to a minimum, with race teams paying minute attention to aerodynamic design to keep wind resistance to a minimum.

One of the most important engineering challenges is to optimize the efficiency of the motor and battery management systems. The aim is to achieve better than 99% efficiency in the various power conversion circuits, the most important being the solar panels, the battery and its management system, the inverter, which converts the DC output from the solar converter to the AC supplied to the motor, and the motor itself.

Typically, a DC solar conversion circuit consists of a Maximum Power Point Tracking (MPPT) algorithm, to optimize the panel's voltage with reference to the sun's brightness and angle of incidence, as well the solar cell temperature, and a



Photo: Jerome Wassenaar

Solar Team Twente from the Netherlands entered its Red E car in the World Solar Team Challenge, which sets entrants the goal of finishing a 3,020km (1,876 mile) race using only power harvested from the sun and generated into electricity

converter circuit to boost the voltage from the solar array to the required input voltage of the inverter.

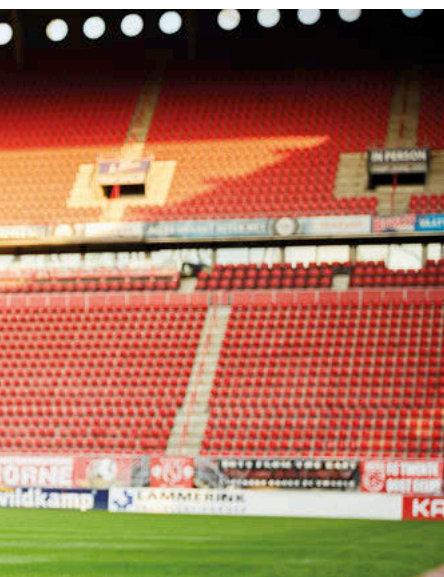
The goal of every team is to finish the race with zero energy remaining in the battery, so the state of the battery's charge must also be precisely regulated. This will, therefore, enable the driver to maximize total energy usage and achieve the highest possible speed for the longest possible distance

without running out of power. The more accurately the charging state can be measured, the more confidently the driver and race team can set the optimum speed, given the prevailing and forecasted weather conditions.

Given that the difference in the average speeds between this year's winner and second place was just 0.5km/h (0.6%), it is even clearer why even the smallest improvement

in conversion efficiency could make a difference between winning and losing, both for the race and our global efforts to maximize the potential of solar power.

To be able to measure potentially small improvements in efficiency requires a sensitive and accurate power measurement system. The accuracy needs to be high because it needs to be better than the very small percentage improvement that



The WT500 Precision Power Analyzer provides simultaneous measurement of voltage, current, power, and harmonics



Photo: Martina Ketelaar.



Photo: Martina Ketelaar.

Using a 2.64m² Gallium Arsenide solar panel to power an engine integrated into its rear wheel, a power analyzer helped the team measure and maximize its efficiency

is being measured in order to validate it.

A variety of such high accuracy measurements are required in the development of a World Solar Team Challenge car. With an efficiency of 99.65% in a solar DC conversion circuit, the maximum possible improvement being chased is as

little as 0.35%. The accuracy of the car's 'fuel gauge', the on-board sensor measuring the battery's state of charge, needs to be validated. This system measures current flowing into the battery (from the solar panels) and flowing out of the battery (to the motor). By subtracting the output from the

Measuring only 2.9m (9.5ft) long and 1.4m (4.5ft) wide, the Red E was the smallest car in the competition

input, the residual charge in the battery can be calculated. This requires extremely accurate continuous measurement of current flows. The power output of the motor system, including the inverter and the motor itself, needs to be measured at a range of power input values, to be able to refine the design and incrementally improve its efficiency. This requires extremely accurate power analysis at a high sampling frequency.

The Yokogawa WT5000 Precision Power Analyzer is meeting these solar race team needs. In one case, the power measurement of the WT5000 was seen to be so precise that it detected a small power loss attributed to a change of resistance in the connector linking the solar

converter module to the battery. The WT5000 has a specified basic AC power measurement accuracy of $\pm 0.03\%$ and a DC measurement accuracy of $\pm 0.07\%$. The measurement bandwidths of 10MHz for voltage and 5MHz for current greatly exceed the switching frequency of a solar converter, and the sampling rate of 10Msamples/s meets the data refresh rate required to validate the fuel gauge system. The wide dynamic current range of the WT5000 is therefore also indispensable for tests on energy-saving designs. Users are able to make measurements on up to seven inputs simultaneously and view them all together on the high-resolution 10.1in touchscreen.

The next Bridgestone World Solar Team Challenge will take place in 2021, which may see even less difference between the teams due to the use of high precision power measuring instruments such as the Yokogawa WT5000, to validate the higher conversion efficiencies, and the race will ultimately be decided on aerodynamics, weight and its distribution, and team decisions. ©

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Introducing DC charging for the home

To support the changing needs of our electric future, an 11kW DC charger offers high efficiency, optimal functionality and design, without the need for an on-board charger

► The requirements of our electric future are changing. According to the International Energy Agency (IEA), the average electric vehicle battery capacity has increased from 20-30kWh in 2012 to 70-80kWh in 2018. In parallel, the public DC charging network is also rapidly growing, and today's battery capacities are capable of delivering an average of 354km (220 miles) on a full charge. With the average single day commute around 64km (40 miles) in distance, it is uncommon for BEVs to run the battery flat. As a result, bulky onboard chargers are becoming redundant as they no longer serve as the fail-safe device they once did. This is therefore beneficial to car manufacturers as manufacturing and material costs are reduced thanks to a more simplified vehicle architecture.

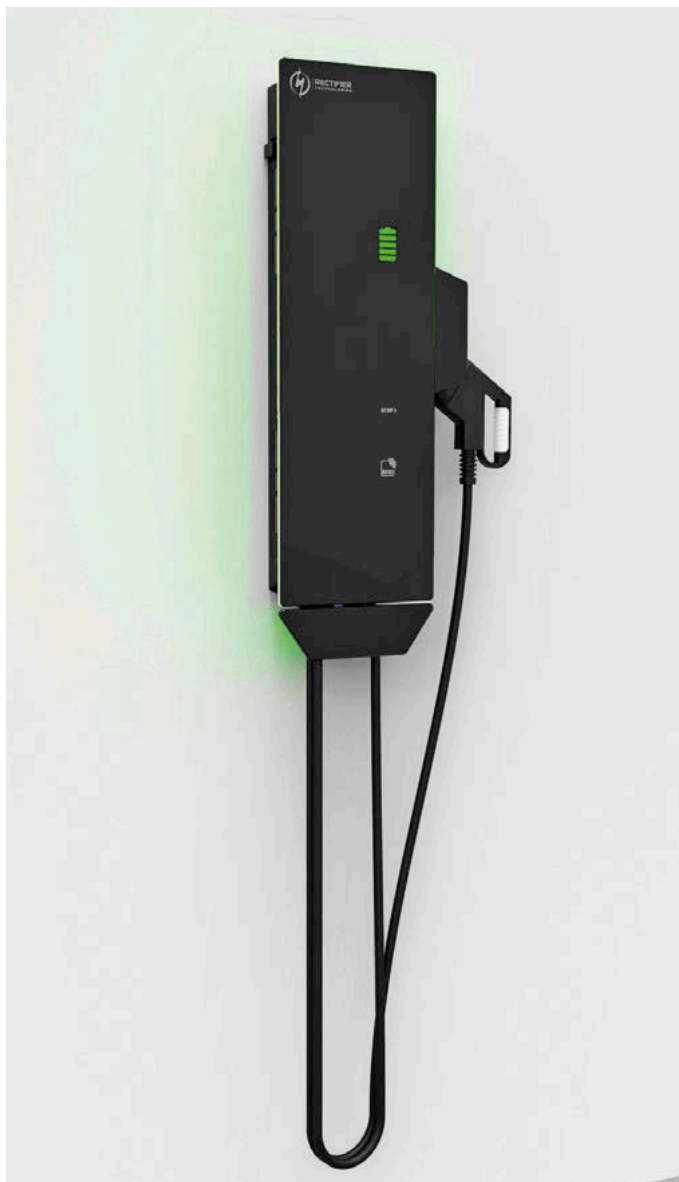
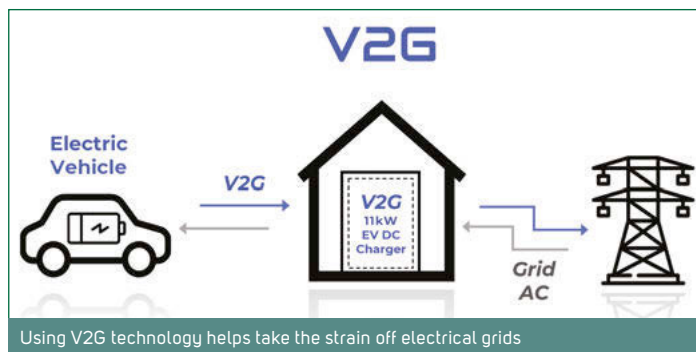
Rectifier Technologies, which specializes in developing and manufacturing high efficiency power conversion products, has leveraged its expertise to deliver a new 11kW DC charger. The innovative product has been engineered to lead the transformation the electric vehicle market is experiencing.

Rectifier Technologies' 11kW DC charger provides a cost-effective DC charging option for the home that is almost 60% faster than the commonly used 7kW AC charger.

Form and function are also balanced with premium design aesthetics and ease of use. With a slimline design the charger is ideal for low-profile wall mounts or narrow spaces, and it offers a simple installation process. The charger is CCS compliant and can be integrated with central management software via OCPP and controlled via an app that is available for iOS or Android. It incorporates high efficiency, optimal functionality and aesthetic design, all without the need for an onboard charger.

As part of its 2020 roadmap, Rectifier Technologies will also be adding Vehicle-to-Grid (V2G) capability to the 11kW DC Charger to address the challenges of grid management and demand arising from the growing number of EVs in the market.

As EV battery capacity has increased by more than 300%, the vehicles themselves no longer need to carry the additional overheads of



The 11kW EV DC charger by Rectifier Technologies is able to provide a 60% faster charge than commonly used 7kW AC domestic chargers



FORM AND FUNCTION

With a slimline design that befits a modern home, the charger can be wall or pole mounted. It is suited for spaces with low-profile wall mounts or narrow spaces such as garages, carports, shopping centers and office buildings. It also offers a simple and cost-effective installation process as the unit is simply hooked onto a bracket that is mounted on the wall and clipped in.

onboard chargers. A lighter, more simplified vehicle platform is now feasible. Premium EV real estate can be saved for additional technology, or larger battery capacities. Rectifier Technologies' core development goal was to design a charger that makes this possible.

The 11kW DC is designed for overnight charging in homes with 3-phase AC supplies. It strikes a balance between efficiency and reliability as it is almost 60% faster than the commonly used 7kW AC charger, and homes cannot support the next available 24kW DC charger.

Another key development consideration is the fact that the adoption of EVs is expected to reach 55 million vehicles in 2025 (IEA). At this rate, it is not possible for the existing grid infrastructure to support the growing load of owners charging their vehicles, particularly at peak electricity usage hours. To overcome the issues of grid load management, Rectifier Technologies will be integrating bi-directional capabilities with its 11kW DC charger by 2020. This will allow electricity from the EV battery to be returned to the grid (V2G Chademo) and with careful control, EV charging can be efficiently balanced throughout a 24-hour period.



Rectifier Technologies specializes in developing and manufacturing high-efficiency power conversion products

"Our 11kW DC charger was engineered to meet the changing needs of an electric future. We understand the rapid changes the industry is facing, and we are prepared to address them. With the rapid uptake of electric vehicles in the market we're also excited to launch a new way of charging

at home. Our bi-directional technology is expected to be ready by 2020," says Yanbin Wang, CEO of Rectifier Technologies.

Rectifier Technologies has the advantage of over 26 years of experience and a global reach, which allows for collaborative business opportunities and bespoke

support. It has partnered with experts across various industries including e-mobility solution providers to meet the changing needs of our electric future. ☺

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Next-gen circuit protection

A new three-in-one solution offers all the switching and protection function an EV needs in one unit

▶ A trend was developing in the electric vehicle (EV) sector: most of the newest and most innovative vehicles were rapidly increasing in current levels, yet the majority of EV components available weren't designed to accommodate such power loads.

Eaton spotted this trend and, to address this need, introduced Breaktor, an advanced circuit protection solution for EVs that combines the function of fuses, pyro switches, and contactors into a single coordinated device.

Conventional EV systems rely on fuses and contactors for circuit protection. However, as continuous current requirements increase, this combination has limitations – mainly due to the lack of robustness of contactors, unable to protect on low overloads together with adequately sized fuses.

Conventional protection has contradicting design requirements that create coordination challenges, which can lead to nuisance-tripping and significantly reduced reaction time in short circuits or overloads, especially in higher-powered battery electric vehicle (BEV) applications.

With less than 5-millisecond actuation up to 1,000 volts and 30,000 amps, Breaktor improves vehicle safety and protects components from any level of overcurrent condition more effectively than traditional circuit protection methods.

The circuit protector also has a consistent reaction time with no fatigue. It is a new technology that provides all switching and protection function in one unit by combining the contactor structure with DC arc steering. Breaktor also offers load breaking as well as overload and short-circuit breaking ability.

In the event of a collision, it can work in tandem with a vehicle's

safety systems, which allows Breaktor to quickly disconnect the high-voltage battery from the rest of the vehicle for unparalleled protection and safety in the event of any overcurrent condition, including a collision.

It is a self-triggering device, able to sense a current spike and interrupt the circuit on top of external triggering, for improved safety and reliability. Plus, Breaktor is resettable – there are no device replacements required, which enables reactivation of the device following a functionality check, reducing the cost for both the OEM and consumer, as well as improving customer satisfaction.

Breaktor provides EV manufacturers with additional

benefits including its current-limiting feature, which improves system level protection in the event of a short circuit. It also functions independent of current direction, which allows for both charging and driving use under full electrical load, and it is available in multiple configurations, including voltage levels and multi-pole configurations.

Eaton has produced industrial circuit breakers and relays for more than 70 years, so even the highest vehicle system voltage is still considered low or medium-voltage in industrial applications.

Breaktor leverages this industrial technology and Eaton automotive expertise to improve performance and reliability while providing architecture simplification.

Eaton's Breaktor protects components by offering 5-millisecond actuation up to 1,000 volts and 30,000 amps

Breaktor is self-triggering and resettable, plus it works with an EV's safety systems to disconnect the battery from the rest of the vehicle if required



Eaton has more than 15 years of expertise in developing hybrid systems with more than 15,000 HEV and PHEV systems on the road in the US, Europe, China and other Asia-Pacific markets. Eaton's high-voltage, fast-acting fuses are found in nearly half of global electrified cars, and power electronics on a leading European battery-electric vehicle platform.

Breaktor is the latest product innovation in Eaton's eMobility business portfolio, developed as a result of combining Eaton's electrical knowledge with its long history of vehicle expertise. ©

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EVSE infrastructure

Electric vehicles are here to stay, but the success of the electrification movement will be heavily reliant on development of innovative electric vehicle supply equipment solutions

► The combination of more competitively priced EVs and improvements in battery technology have provided peace of mind for drivers looking to travel 200 miles on a single charge. Likewise, the commercial vehicle segment is also embracing the switch. Public and private transportation entities are overhauling their commercial fleets from combustion to alternative fuel engines. In the USA alone, it is estimated that the engines of some 34 million commercial vehicles will be converted to or replaced by alternative fuel engines before 2025.

Despite significant strides in the right direction, most auto makers seem to agree that the industry faces two major obstacles to the adoption of electric vehicles: the need for more government incentives and the installation of a network of electric vehicle supply equipment (EVSE).

Transportation entities are facing additional challenges in construction of EVSE network infrastructure. In highly populated cities, for instance, commercial fleet entities lack adequate space to install EVSE pedestal ports. Most



Overhead distribution systems counter the inflexibility of pedestals

multiple electric charging cords and maximum space savings.

Overhead busways ease the uncertainty of elevated EVSE installation costs. The industry recognizes that EVSE installation costs are highly variable, and there is no clear consensus as to which direction installation costs are heading. Starline Track Busway offers an innovative, yet simple, maintenance-free design that allows reconfiguration, repositioning and expansion. Busway systems also eliminate the costly and time-consuming installation of subterranean concrete pads, anchor bolts and conduit from the circuit panel to the charging station. Real-time power monitoring, from load balancing to data management, is an integral aspect of the electric vehicle charging infrastructure. Starline's Critical Power Monitor is uniquely configured to capture data granularity levels ranging from an entire feed down to each individual EVSE charger.

As EVSE networks continue to transform, costly and outdated technology will be increasingly phased out by more innovative solutions. Commercial and consumer demand calls for scalable, reconfigurable charging systems. This is required to maintain a competitive advantage in such a swiftly emerging market. More than ever, the global automotive sector appears to be led by forward-thinking companies and institutions. Equally innovative EVSE infrastructure will be needed for electric vehicles to reach their full potential. ☺



Starline offers an overhead charging system with instant access to power at the point of use

pedestal chargers have a limited number of plugs that can be used simultaneously. Furthermore, being stationary makes them inflexible for future changes or reconfigurations.

To address some of these constraints, users are considering alternative overhead systems to distribute power. Starline Track Busway has been a leader in flexible power distribution since electric vehicles were first introduced in the market. Starline offers an overhead busway system with a continuous open channel that allows instant access to power at any point along the busway. This solution provides commercial fleets with unmatched flexibility for power reconfiguration, allowing a fast and reliable point of use power source,

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HIGH PERFORMANCE DRIVE SYSTEMS



Automotive research and development is constantly pushing the boundaries of technology in the quest for higher efficiencies and higher performance. The engineering team at Unico have been challenged with developing solutions for high speed, high performance, direct coupled dynamometers for **e-Motor test stands**.

Using Unico's modular approach to drive design, these systems have been manufactured with such options as integrated bi-directional DC power supplies and universal inverter modules for driving the UUT irrespective of the motor technology used, IPM or SPM. These elements are all configured to operate from a single regenerative active front end which will place a lower burden on the power infrastructure and keep costs down.

Unico offers tailored solutions across a wide range of performance capabilities. Here are some examples of eMotor test benches we have recently developed:

- | | | | |
|------------------------------|-------|-------|-------------------------------|
| • Max speed 20,000rpm | 400kW | 545NM | Inertia 0.065kgm ² |
| • Max speed 25,000rpm | 250kW | 300NM | Inertia 0.052kgm ² |
| • Max speed 30,000rpm | 240kW | 320NM | Inertia 0.01kgm ² |

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Hydrogen goes further

How hydrogen fuel cells can set minds at rest by extending the range of electric vehicles

▶ Range anxiety – where drivers worry that their battery will run out of power before they reach their destination – is still preventing the widespread uptake of electric vehicles (EVs). For the car-buying public it represents a serious issue, and for commercial users it is absolutely critical, with jobs and businesses being directly affected.

The average trip in an electric car is just 10 miles, but commercial vans and buses have to run all day long. Starting, stopping and accelerating all impact the performance of the EV's battery pack, and range can also decline as the battery pack starts to age.

By way of an example, the latest 88-passenger electric bus being developed by Daimler has a massive 243kWh Li-ion battery resource to power its motors. However, even this is not enough to handle all the routes that buses will normally have to travel, powering only about 80% of the journeys. This leaves bus operators with a headache – electric versions are applicable for some routes and diesel-powered versions are still needed for others.

Meanwhile, van operators face a different challenge. The more batteries the van needs for its rounds, the fewer packages it can deliver, because the batteries take up valuable space.

These and other kinds of commercial enterprises want to adopt electric power to lower their running costs and tackle the growing emissions problem, but they must ensure their vehicles return at the end of each day for recharging. While research into increasing battery capacity continues, a practical solution is needed today.

By having a charged battery working in tandem with a hydrogen gas reserve, the EV range can be



Fuel cell hybrid electric buses have a much greater range and longer battery life than regular EVs

extended substantially. Hydrogen is combined with oxygen in a fuel cell to generate electricity for driving the motors directly or, more often, to keep batteries topped up. This has the added benefit of avoiding too much current drain on the batteries, which can reduce their lifespan.

A hydrogen range extender can be located on an EV's roof, thereby avoiding taking up valuable cargo/passenger space. This also means that flammable hydrogen is kept well away from Li-ion battery packs, which can potentially overheat.

The fuel cell employed in this arrangement comprises a stack of proton exchange membranes that can handle the combination of hydrogen and oxygen. Because the only by-product from the fuel cell is water, the vehicle maintains a very low overall carbon footprint, especially if an electrolysis process powered by renewable energy produces the hydrogen.

This all sounds very appealing, and fleets of vans employing this technology are already starting to hit UK roads, but there are still certain technical difficulties to consider. The hydrogen is stored at 300bar in the vehicle, which requires a robust tank with reliable pressure valves – and these have associated engineering costs. Then there is the matter of hydrogen refueling, because there is very little supporting infrastructure currently in place.

To address this, many companies are now installing electrolyzers to produce hydrogen on site. These are built-in 40-foot containers, making them easy to manage. It should be noted, though, that the hydrogen changes temperature as it moves from the electrolyzer storage into the range extender, so cooling is required.

Hydrogen can also be distributed by specialty chemical suppliers in canisters. These can boost the

range of smaller vans without having to worry about refueling infrastructure. There are also moves in the UK to utilize part of the already-established natural gas delivery network to transport hydrogen for this purpose.

Battery power, along with fuel cell range extension, offers an added dimension to commercial fleet operators' e-mobility strategies. Whereas pure-play EVs struggle with a full day's usage, range extenders can provide that necessary extra capacity, and the technology also helps protect the battery.

While battery packs and fuel cells both have to be replaced around every 20,000 miles, by working together they can keep commercial vehicles running much longer. ☉

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Direct connection

Replacing the shielded header with an all-plastic module offers more cost-efficient and flexible high-voltage connections

► A new solution is able to offer the HEV/PHEV/EV sector new opportunities to reduce cost, enhance design flexibility and streamline manufacturing for auxiliary device connections.

The Apex 280 Direct Mate, from Aptiv and supported by Power & Signal Group (PSG), a global distributor dedicated to the transportation industry, in contrast to traditional high-power connections, replaces the shielded header with an all-plastic inner terminal module.

Comprising only the male 2.8mm terminal pins and a plastic holder, this simple interface is manufactured to the specific requirements of the application and installed inside the device.

The crimped female terminals incorporated in the Apex 280 connect to the inner terminal module. Offering both bundled or individual shielding options, device makers can effortlessly implement this connector solution in auxiliary systems such as air-conditioning units, PTC heaters and inverters.

Swapping the traditional shielded header for screwed connections means that the risk of fretting

corrosion is significantly reduced. Another key advantage of screwing direct to the front of the device is the outstanding V2-rated vibration performance that is delivered.

Aptiv's proven Apex 2.8mm terminals are used, supporting DC voltages of up to 850V and currents of up to 40A. Cables ranging from 2.5mm² to 6mm² can be used and

the device is sealed to IP67, with finger-proof IP2XB protection. In addition, the Apex 280 Direct Mate incorporates an HVIL (High Voltage Interlock Loop) feature for safe disconnections.

Characterized by a high degree of flexibility and manufacturing efficiency, the product facilitates both bundled and individual cable-shielding strategies. It therefore addresses the needs of around 90% of the world's leading automotive OEMs, right across North America, Asia and Europe.

That means device makers can supply numerous different OEM customers with a single, standardized solution, avoiding the delays and extra costs that are incurred when design changes are needed. High-performance EMC and RFI shielding is achieved across both techniques.

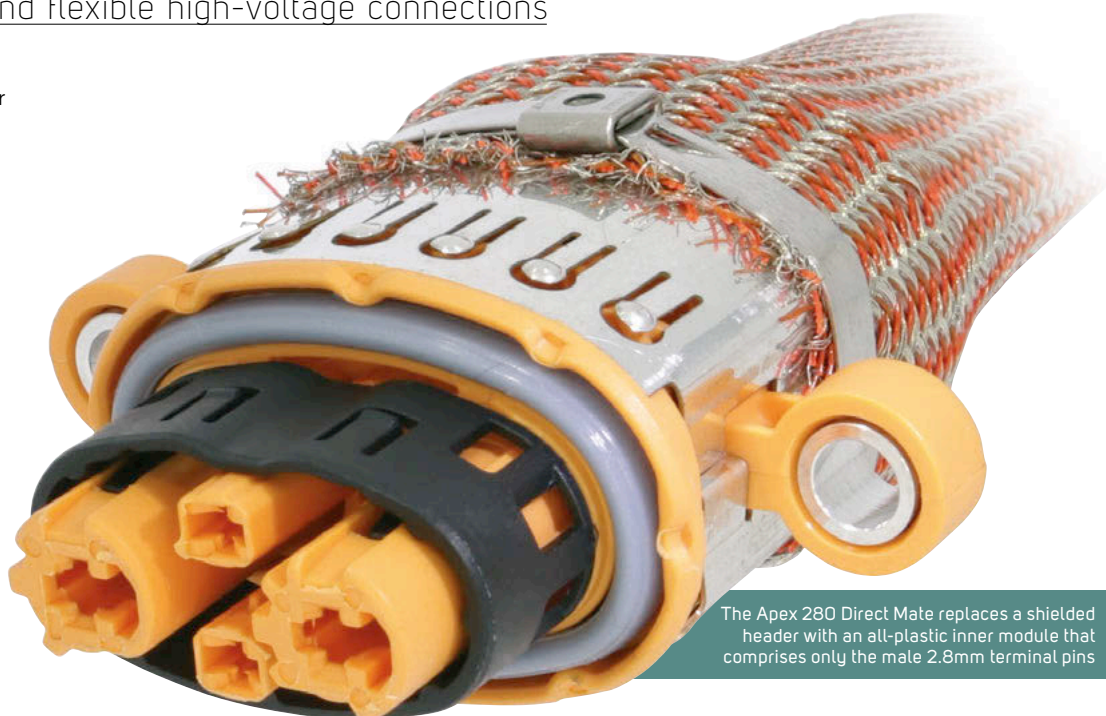
With consumer enthusiasm for vehicle electrification accelerating fast, and OEM development plans

ramping up at similar speed, the need to improve affordability and secure further build cost reductions are now priorities throughout the HEV/PHEV/EV sector. OEMs and device makers that are keen to use Apex 280 Direct Mate to help achieve these goals can also draw on comprehensive, added value support from PSG, a company of Arrow Electronics.

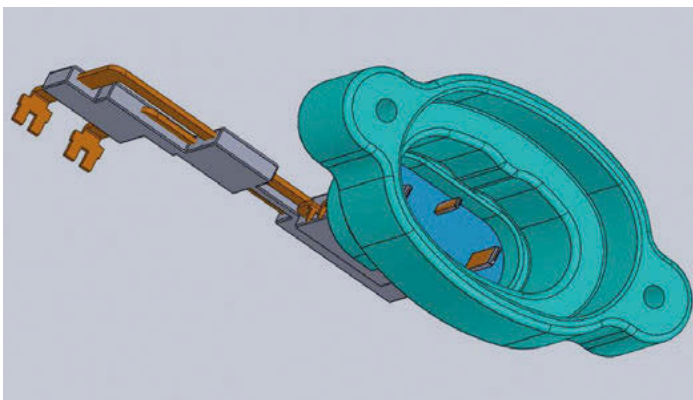
Building on a partnership with Aptiv that stretches back to 1982, PSG provides a service portfolio that extends far beyond the traditional component distribution model.

For the Apex 280 Direct Mate, that includes the ability to assist clients at every stage of the design and manufacture of inner terminal modules, or indeed provide a tailored harness solution fully assembled to customer needs. ©

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The Apex 280 Direct Mate replaces a shielded header with an all-plastic inner module that comprises only the male 2.8mm terminal pins



PSG will work with clients on the design and manufacture of the terminal modules

The  **people**
that make the **additives**
that go into the **oil** 
that **lubricates** the
 **transmission**
that **drives** the wheels 
smoothly  in **electrified**
passenger and
commercial **vehicles.**

Driving down costs

OEMs are challenged to defossilise mobility. One way of doing it is by driving down the cost of electrification, and key to this is a systems approach to engineering

► Making the transport sector zero fossil carbon to help mitigate climate change is a priority, yet removing the internal combustion engine from the vehicle parc and powering all global transport by battery electric technologies is unlikely to be achievable at the pace required to mitigate climate change.

CO₂ emissions targets and range limitations for electric vehicles will ensure the combustion engine operating on reduced fossil fuel content will remain a key element of automotive and industrial propulsion systems for many decades. The Low Carbon Vehicle Partnership calculates that increasing the UK bio-fuel percentage to 9.75% on average as a drop-in fuel modification by 2020 could save two million tonnes of CO₂ in the UK transport sector. Significantly greater percentage bio-fuel is already in use in the EU.

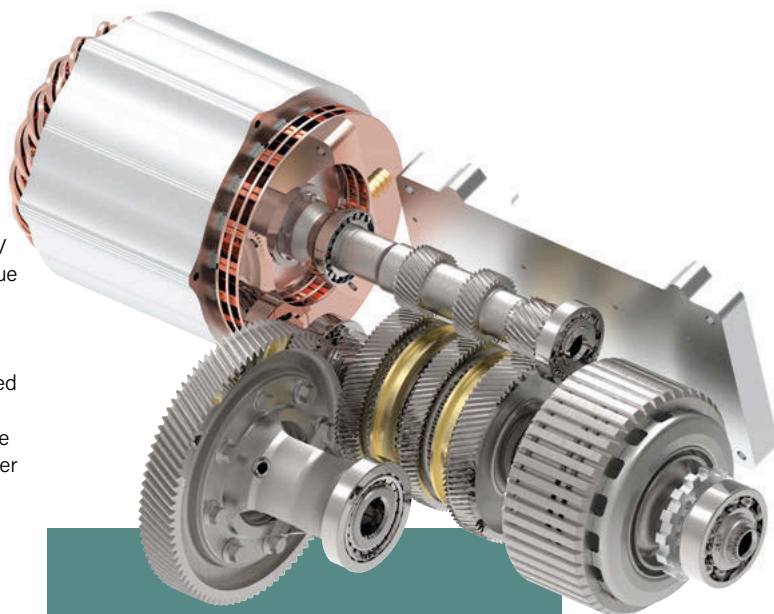
Ricardo advocates a holistic view of total lifecycle impacts and sustainability, and risk-mitigated, cost-effective deployable propulsion systems. A systems approach that combines high-efficiency propulsion options targeting low-to-zero

air-quality impact delivers synergistic weight and cost reductions and supports an integrated multi-energy vector approach to defossilization.

Ricardo's systems approach to electrification comprises several core technologies. The Magma xEV combustion system delivers 45% true brake thermal efficiency (BTE) in a hybridized car or light commercial vehicle powertrain. It has been developed using Ricardo's advanced combustion simulation tools, and the concept is particularly attractive for series-hybrid and range-extender powertrain applications. Routes to 50% BTE are understood, as well as compatibility with low-carbon fossil fuels.

Ricardo's dedicated hybrid engine for hybrid, PHEV and range-extender applications offers significant weight, friction, thermal and cost optimization. Novel approaches to design, integration, materials selection and combustion system application have shaped future engine family design and signpost solutions for cost-effective hybridized powertrains.

A pioneer of electrified drive units (EDU) for hybrid and full electric vehicles, Ricardo's multi-speed electrified drive unit maximizes overall EV or hybridized system efficiency, offering systems weight and cost reduction along with package space optimization. The three-speed power-shifting concept demonstrates the advantages of a systems approach: a 4-7% increase in range; substantial vehicle launch and top-speed improvements; 50% motor volume reduction; and the possible reduction in battery cells for the same range or the ability to sell the vehicle in a higher class with greater range and sales price. The systems approach is scalable from one to three speeds, as determined



Ricardo's multi-speed electrified drive unit maximises overall system efficiency while reducing weight and cost

by the complete system design and optimization toolchain. This also advises selection and development of motor technology and design features, optimizes the number of gears and ratios, and optimizes battery capacity for a given vehicle requirement set while minimizing total vehicle bill of materials cost.

The Ricardo 800V automotive battery pack exemplifies the design features and thought leadership the company delivers in high-voltage batteries. It is an enabler for lighter, more efficient power networks on the vehicle, ultra-fast charging and high system power output. Thermal systems technology options include immersion cooling, rapid-charging cooling and control approaches that minimise battery heating and cooling systems energy requirements as a complete vehicle thermal system, to deliver significantly improved range.

Applicable to all these systems – internal combustion engine, electric motor, power electronics,

battery, cabin, cooling and air conditioning (AC) circuits – Ricardo's advanced thermal systems offerings bring together vehicle multi-temperature cooling circuits and direct/indirect heat pumps that enable the recovery of waste heat from electric components.

Ricardo Integrated Thermal Management (ITM) balances heating and cooling power among the components, together with heat storage using actuators and sensors with Model Predictive Control to minimise energy consumption from ancillaries such as fans, pumps and AC compressors.

The Ricardo systems approach to driving cost out of electrification can be applied to the product challenges faced by OEMs as they work hard to achieve the goal of mitigating climate change. ☼



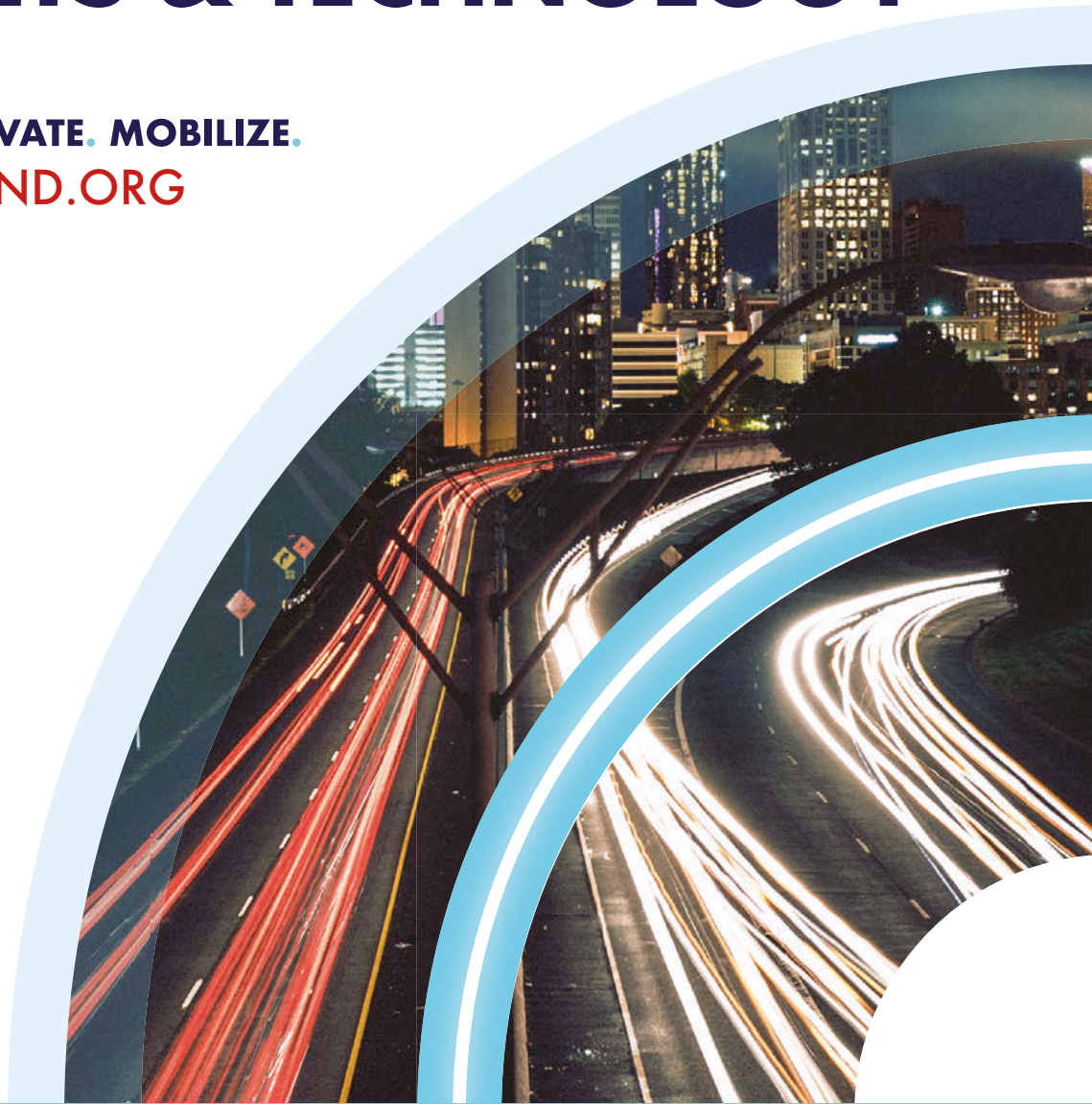
Ricardo's Future Vehicle Architecture (FuVA)

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Performance testing

A battery cell test system with fast current response is able to provide manufacturers a more efficient and cost-effective method for product verification

▶ As the key component of electric vehicles, the lithium-ion battery (LIB) must undergo and pass each car manufacturer's most stringent performance tests to guard personal safety and keep risks at a minimum. These diverse tests are complex and time-consuming. It requires specialized test equipment to test multiple channels simultaneously in order to reduce the time for the complete product verification. The Chroma 17011 regenerative AC/DC bidirectional battery test system passed the demanding performance tests of major Japanese battery manufacturers. The test device performed with excellence on aspects such as current response, measurement accuracy, output dynamic waveforms, stability, and controlled feedback speed.

Constant power (CP) is the most common testing mode for LIB. However, the CP output is affected by electric potential differences in the battery's internal resistance and easily generates overshoot. Creating fast output response without overshoot remains a complex issue for battery test equipment. LIB testing requires long-term simulation of actual driving conditions and fast output response to reduce distortions, while running a LIB beyond the specified working range will invariably affect the battery life to a certain extent, increase risks in verification, and deviate the test results. Chroma offers excellent CP output performance with output response time of less than 3.5m/s and no power overshoot. Moreover, the comprehensive safety protection mechanism makes the Chroma 17011 an ideal solution for LIB testing.

Chroma not only provides standard stand-alone and system products, but also develops reliable

and customized integrated services to provide the best complete solution depending on battery shape, electrodes, safety device, environmental chamber integration, and more. One particular Taiwanese materials plant has adopted a Chroma 17011 equipped with integrated environmental chamber

The Chroma 17011 test system verifies electric vehicle batteries quickly, comprehensively and accurately



CHROMA 17011 KEY FEATURES

- Current output up to 1200A
- Fast current response
- Multiple current range with accuracy
- CC-CV transition with no delay and with no overshoot
- CP mode with fast response and with no overshoot
- Fast Waveform simulation with update rate up to 10m/s and cut-off judgement



and fixture that is designed for simultaneous pouch cell as well as coin cell battery testing.

Chroma devises its battery testing devices with low contact resistance, robustness, temperature uniformity, durability, and maintainability, while providing optimal application flexibility through compatibility with a wide range of battery products. Following this, Chroma consults the user's habits and the moving lines through the production space. Chroma then offers a customized design that enhances daily operation, improves test results, and solves all testing problems. ©

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September 23, 2020



Challenges ahead

How smart electric vehicle charging technology and engineering will make the electric future possible

► The biggest challenge on the road to electrification is infrastructure. In the United States, Germany, Japan and China, the infrastructure to support a large number of DC charging stations, especially high-power stations, does not yet exist.

If, for example, EV owners starting out on a holiday weekend were to all charge their cars at the very same time, in many regions this will cause excessive demands on the power grid. Industry leaders need to work with governments and electric power utilities to plan for future support of electric vehicles. Every three EVs sold will have the similar effect of adding one new household to electrical demand.

Another challenge to the industry is the high level of power required for DC fast charging. For a 350kW charging station, engineers must design for very high currents, including a thick charging cable. However, the cable cannot be so heavy that consumers cannot handle the nozzle, which limits the size of the cable, which in turn increases the resistance and the heat. Designers must therefore find a means to cool the cable. What's more, designers must protect consumers and equipment from the risk of electric shock, fire, arc-flash, and explosion.

Lack of standardization is also an issue. Different companies and organizational bodies are working to a number of different standards. In principle, differing standards across regions are not a big issue, because EV drivers will not drive from Japan to Germany. Theoretically, if there is standardization within each region such as the Americas, Europe, and Asia, the industry can move forward.

However, having different standards limits the economies of scale. Vehicles and charging



The EV industry must address multiple roadblocks ranging from infrastructure issues to standardization and safety

stations in different regions will need different components, and therefore the industry will not achieve the same economies of scale as it could achieve by having one universal set of standards.

The introduction of new infrastructure hardware is seeing new product design and usage. Here, there are several areas of concern including safety, reliability, and future-proofing.

When it comes to electrical safety, high-power DC charging is a completely new application. Presently, only qualified, trained technicians are allowed to approach electrical equipment that carries high power, and they must wear safety apparel. Charging stations are used by the general public, including outdoors in the rain, which increases the danger of electric shock and faults. Pioneering engineering

solutions must be developed that keep consumers safe.

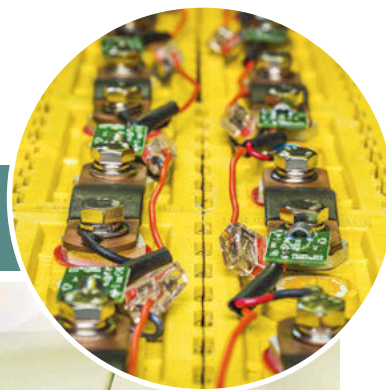
In contrast to consumer devices such as laptops that typically have a lifetime of three to five years, high-power DC charging stations are expensive, so buyers need them to last for 10 years or more, in order to get a return on investment. Therefore, it is critical that the electrical components specified for a charging station can survive harsh outdoor environmental and operating conditions. While the charging stations are not located on a vehicle, and therefore automotive-rated components are not required, many specifiers will still seek equivalent reliability.

Power, as measured in watts, is the product of voltage and current. The easiest way to design for higher current is to increase the thickness of the cables. However, due to the

limit to the weight that consumers can handle, the only option is to increase the voltage. The expectation is that DC fast charging stations will operate at 1,000 volts at the nozzle. High voltage, along with highly efficient power conversion, will enable designers to reduce system size and use less expensive cooling methods. However, with the increased voltage escalates the risk of fault and shock, so designers will need to develop fool-proof safety strategies.

As other industries have shown in the past, fast adoption and demand can drive improvements that solve current challenges and political regulations. The EV industry must be ready for accelerated demand. ©

Smarter electrical components are critical to support EV development



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Ten years on...

Lessons learned in China over the past decade can help as the European Union pushes truck and bus electrification

► It is 10 years now since the Chinese government started pushing for vehicle electrification, particularly the rolling stock in the country's mega-cities. And the move has been quite a success story, with 99% of the global electrified bus stock – close to 400,000 units – operating on Chinese city roads by the end of 2017.

It has taken Europe a little longer to move, but in the summer of 2019 the European Parliament established binding regulations that will force lorry manufacturers to reduce CO₂ emissions from new heavy commercial vehicles by an average of 15% from 2025 compared to 2019-2020, and then by 30% from 2030.

Emission-free and low-emission vehicles will fall under a super-credits system until 2024, and by the following year manufacturers must also ensure that zero-emission or low-emission vehicles account for at least 2% of all new vehicles sold.

On top of that, EU member states have been set binding targets for using emission-free commercial vehicles in public procurement.

For example, Germany must procure at least 38.5% emission-free vehicles from public orders of light commercial vehicles. The figure is 10% for heavy commercial vehicles (15% from 2026) and for buses it is 45% (65% from 2026).

Semikron, a leading supplier of power electronics equipment, has been providing products for vehicle electrification for more than 25 years. Starting with material-handling applications such as forklifts in the 1990s, Semikron has since equipped more than 1.5 million vehicles for material handling and beyond 200,000 passenger cars with power electronic products.



Semikron has shipped more than 50,000 traction inverters from the SKAI2HV product family for use in China's growing fleet of electric buses

The company has also contributed significantly to the electrification of Chinese city buses, shipping more than 50,000 traction inverters from the SKAI2HV product family. Since 2013, these inverters have accumulated more than one billion field-operating hours.

The resulting field data underlines the fundamental advantages of the solder-free assembly of power semiconductors as incorporated in SKAI2HV inverters. The lack of solder joints in the SKAI2HV power semiconductor assembly enables the product to fulfil the challenging requirements for load power cycling, which is a direct consequence of the continuous accelerations and decelerations that take place in city bus drive cycles.

Since the end of 2018, the second edition of the automotive functional safety standard ISO26262 has applied to the development

programs of commercial vehicles with a gross weight of more than 3.5 tons. The manufacturers of electrified commercial vehicles have analyzed their vehicle hazards and risks for potential failures.

To mitigate those risks, the suppliers of key components such as the traction inverter are now – depending on the chosen vehicle safety concept – often requested to add certain safety requirements into their product specifications.

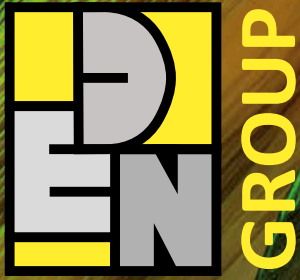
Semikron has prepared itself for these extended requirements and is now jointly customizing its SKAI products in accordance with customers' individual safety goals. Consequently, Semikron certifies its quality management system and software development process in accordance to IATF16949 and Automotive Spice, respectively. All process items of the Automotive Spice standard fully coincide

with the ISO26262 development process steps.

Since launch, the SKAI2HV product family has been available on different integration levels to align it with customer needs. These levels comprise variants with a gate driver interface, which offers direct control of power semiconductor switching signals, or a CAN-bus interface. The required motor control software for the latter is offered by Semikron, but might also be proprietary to the customer.

Semikron will contribute to the European vehicle decarbonization program, and the additional challenges introduced by the new ISO26262:2018 will be covered by the SKAI products that have been proven in use in China since 2013. ©

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Eye on the ball

EV drivetrains are placing new demands on components such as bearings, however advanced bearing technology and materials can overcome this issue

► Bearings, although located deep within the vehicle, are one of the most critical components in contributing to drivetrain efficiencies and delivering reliability for automotive manufacturers.

Breakthroughs in technologies such as batteries, power management electronics and electric motors have paved the way for the dramatic emergence of electric mobility, but every aspect of the EV drivetrain is being advanced in the push for efficiency and reliability.

The demands on bearings and the push for efficiency throughout the drivetrain is prompting OEMs to explore new low-friction approaches rather than the conventional tapered roller bearings that are found in gearboxes and differentials.

Another challenge is the high speed of the electric motors in EVs up to 30,000 rpm speeds, far higher than those found in most industrial applications, are needed to ensure the drivetrain works efficiently. The speed acceleration and temperatures generated by these machines place enormous strain on bearings and their components such as cages and rolling elements.

Bearings running at such high speeds also need effective lubrication and cooling. Without this, there is a high risk of rapid degradation of the bearing components. If not, both races and rollers may overheat, causing premature failure and the need for early replacement.

In addition to high rotational speeds, electric motors can also present further challenges for bearings through electrical discharges. High-frequency voltage switching of the motor inverter can result in current leakage. This current can be conducted through the bearings causing arcs in the

Bearings designed to meet the demands of future vehicles help performance and reliability

rolling contacts and may result in surface fatigue and erosion.

Manufacturers are also developing special lubricants with lower viscosity and special additives in order to reduce power losses from friction and support operations at far higher speeds. However, lower viscosity lubrication can also have an impact on the wear and fatigue characteristics of bearings. Accelerated wear can result in catastrophic failure, having an obvious impact on reliability.

In response to these new demands, manufacturers such as SKF are investing in new technological developments and adapting or redesigning conventional bearings. By redesigning elements such as the polymer cage, rolling components and using special lubricating grease for example, customized and hybrid bearings are already solving some of the fundamental issues that can affect reliability in electric vehicles.

In terms of electrical discharge, ceramic ball bearings are currently the most attractive solution given that ceramics are typically electrically insulating materials.

While using ceramic rolling elements to create a so-called hybrid bearing resolves this issue, it also has the benefit of having roughly half the density of their steel equivalents, ceramics are lighter and therefore tend to run at lower temperatures. In addition, ceramic bearings are much harder than steel so last up to 10 times longer, typically requiring less lubrication.

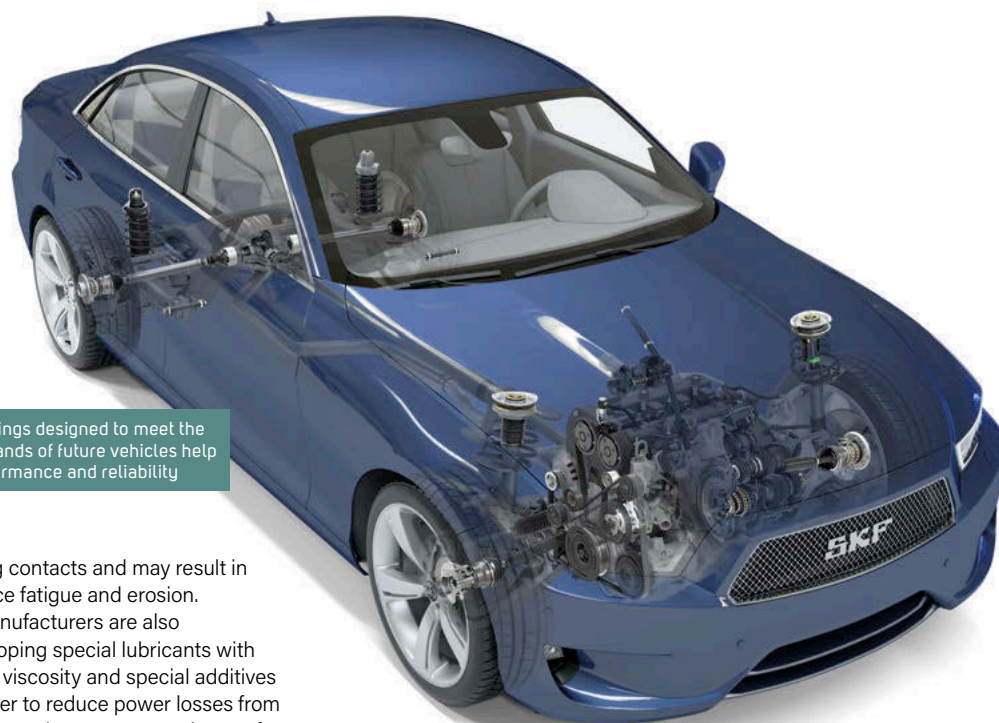
Although currently only around 5% of bearings in EV applications are hybrids featuring ceramic elements, this is beginning to change. The value that hybrid units offer in reliability and extended service life is becoming increasingly recognized and acknowledged.

Another solution that is being explored is carbonitriding bearing raceways for applications where bearings are exposed to contamination or poor lubricants.

Carbonitriding increases the surface hardness and consequently, as with ceramics, increases the in-service lifetime. As the global EV market continues to expand, many more advanced ways of dealing with all the specific conditions required for EVs are also under development. These include special greases that maintain a stable viscosity at higher speeds and temperatures.

Given the new constraints linked to EV technology development, the bearing contribution to the overall system behaviors should not be underestimated. Manufacturers such as SKF are creating bearings that are fit for the future with improvements in performance, efficiency and reliability. 

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Battery safety certification

EV manufacturers can shorten time-to-market with the help of an off-the-shelf, customizable automotive ISO26262 ASIL C compliant BMS platform

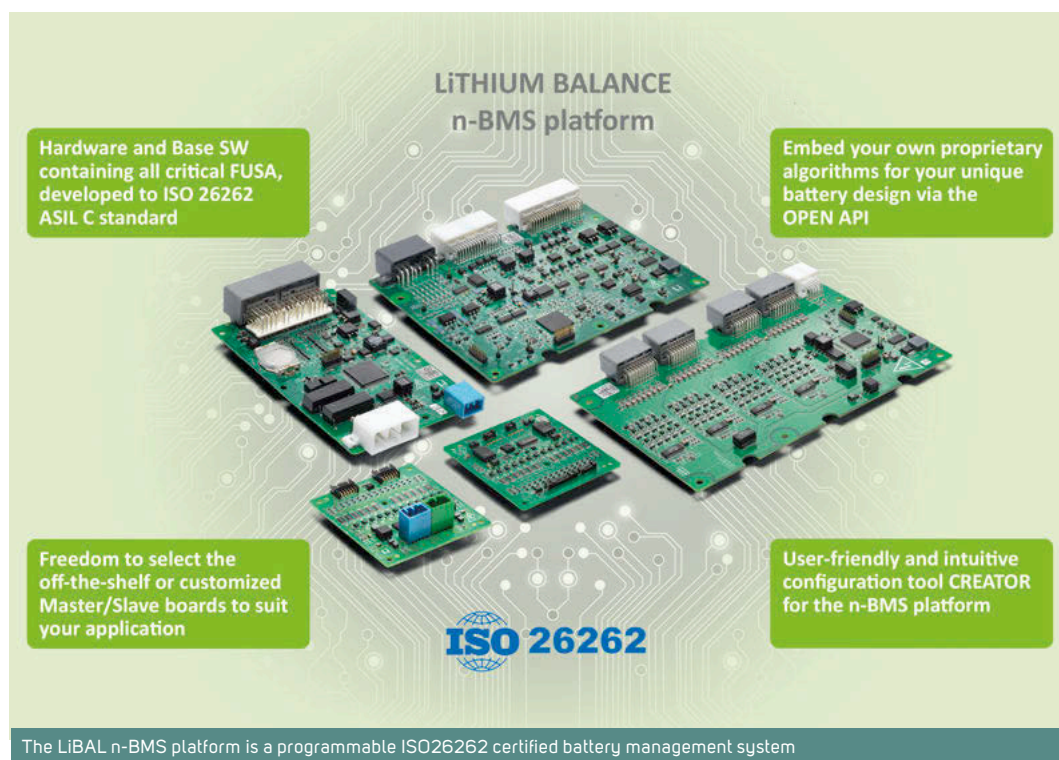
▶ For electric passenger vehicles, full compliance with international safety standard ISO26262 at ASIL C level is gradually becoming an absolute market requirement. Many other EV markets also look to ISO26262 to ensure functional safety of battery driven applications. Since the battery management system (BMS) is at the core of ensuring safety of the battery pack, it is imperative that a BMS is fully ISO26262 compliant and preferably also certified by an independent body. Yet, currently only a few BMS in the market are ISO26262 compliant and certification is rare because the work involved is very time consuming, difficult and expensive.

Lithium Balance experienced this when they developed the ISO26262 ASIL C compliant n-BMS platform. However, in the past two years the company has made the investment to get the next version of the n-BMS fully certified by an external accredited body.

The certification process involves more than 100 critical reports to be analyzed and verified by the external body as well as a series of on-site audits.

Besides analysis during the design stage, such as hazard and operability (HAZOP), fault tree (FTA), failure modes and effects (FMEA), failure modes, effects and diagnostic (FMEDA), this certification process also looks at the entire life cycle of the BMS through the production and service stages of the product.

In a strategic co-operation with Ansys – a leading software company within automotive safety analysis – Lithium Balance has established a model-based approach with a high level of consistency, traceability and efficiency of the automotive functional safety analysis.



The ISO26262 ASIL C compliant hardware design includes a 32-Bit RISC floating-point and dual core CPU on the master, but the n-BMS offers the choice of several slave boards to suit different customer applications such as managing different number of cells per slave, different kinds of connectors or form factors. Slave boards can also be customized to customer needs.

A groundbreaking feature of the ISO26262 ASIL C certified n-BMS platform is an open API that allows the customer to include their own software code without jeopardizing the ISO26262 certification. This is achieved by separating the n-BMS software into two separate layers. The Base Layer Software (BSW) contains all hardware drivers and all of the safety critical functions.

The BSW is part of the ISO26262 certification and cannot be customized by the customer. However, this is possible in the Application Layer Software (ASW) that contains the non-safety critical functions such as SoX algorithms. The two software layers are separated by an open API interface layer to make the ASW programming and its connection to the BSW layer seamless.

The n-BMS comes with a complete and configurable ASW package of functionality from Lithium Balance. However, via the open API the customer can supplement or replace the existing ASW functionality with their own custom and proprietary algorithms and battery models through the open API without jeopardizing

the ISO26262 certification of the platform. This customization can be carried out using the MATLAB toolbox and Simulink codes for fast and efficient high-level, model-based programming.

The solution offers customers an off-the-shelf automotive ISO26262 ASIL C compliant BMS platform, that can be configured and customized by the customers without having to go through the time-consuming and expensive ISO26262 certification process. EV manufacturers can therefore shorten time to market, while at the same time ensuring the functional safety in its battery pack. ©

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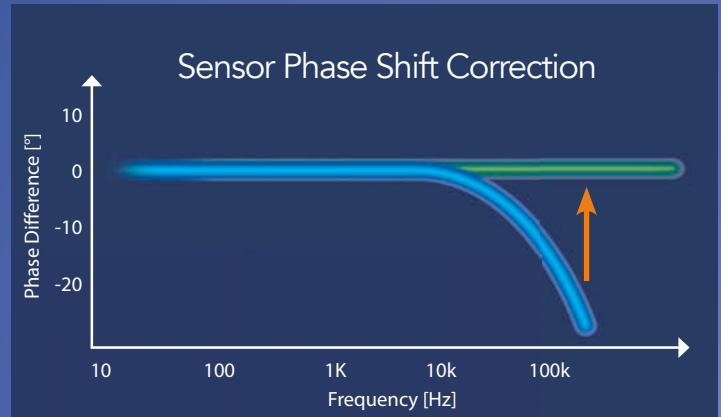
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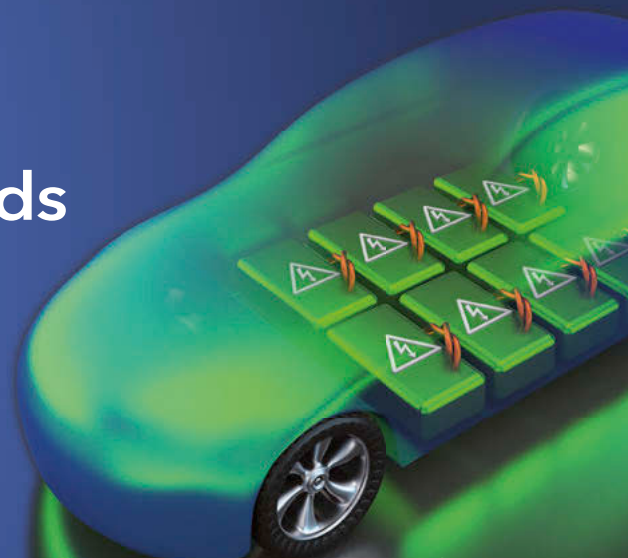
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New age fluid testing

Partnering on new, more targeted tests for electrified transmission fluids can better predict real-world lubricant performance

▶ Drivetrain electrification is a real challenge for lubricant, the one component that touches every part of the transmission. Well-designed lubricants can unlock new engineering ideas, although it's often hard to correlate laboratory performance with real-world use. Still, next-generation lubricants could support a wide range of hardware, from transmissions hybridized with e-motors to new, dedicated hybrid transmissions and full e-drive solutions. Fluid compatibility and electrical and cooling properties will have to supplement core friction performance and parts protection. Determining fluid and additive needs will be essential for controlling risk.

"Unfortunately, current industry tests aren't always wholly relevant to or predictive of lubricant performance in EVs," says Dr Harald Maelger, senior OEM relationship manager at Afton Chemical. "Avoiding the pitfalls requires close partnerships with additive and lubricant suppliers,



New lubricants are tested extensively through five phases before they are allowed to enter production

so OEMs can really benefit from non-standard testing to bridge the gap between laboratory, rig and road."

Afton Chemical is at the forefront of EV fluid testing, with recent advances in three areas: friction durability with thermal stress; gas and liquid phase compatibility; and electrical property changes in ageing fluid. Tests are specifically designed to correlate with field performance to generate robust, reliable fluid recommendations.

Unsurprisingly, Afton examined friction durability first. "The FVA's recent GK test round robin was worrying. The same reference fluid,

under identical conditions, showed friction failure anywhere between 3,500 and 9,300 cycles," says Dr Susie Hurley, senior adviser in ATF R&D at Afton Chemical. "This raises a red flag: fluids meeting OEM specifications on one test rig might not meet them on another, making it even harder to translate results into the real world. Standard testing also overlooks the role of heat, as found in a hybrid transmission."

Afton's own HEV friction durability test combined dedicated friction apparatus with a thermal loop to simulate cooling stresses. Results showed an antagonistic effect, limiting effective fluid life more than anticipated. "We wanted a reliable indicator of field performance, so we tested used as well as new clutch plates," Hurley says. "Plate analysis showed that fluid formulation is paramount, but that if problems do occur, shorter oil drain intervals are effective at restoring performance."

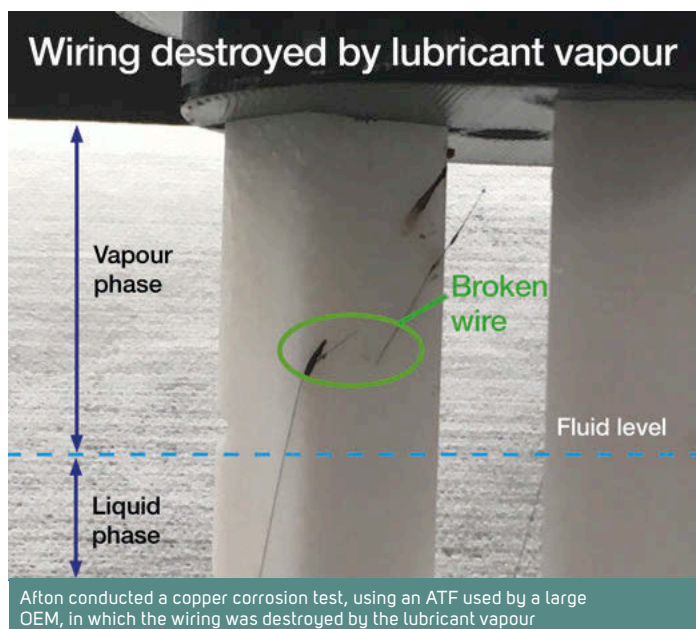
Sensitive e-motor components also demand lubricant compatibility. "Our initial recommendation was to extend the standard copper corrosion test and also measure end-of-test copper in oil," says Hurley. "Screening tests revealed that some commercial fluids are especially aggressive in the gas phase, which is important given the higher temperatures associated with e-motors. We worked very closely with an OEM to develop a simple screener test that correlates to problems experienced in the field."

Fluid conductivity is a third focus. "Naturally, OEMs want to know what the right tests and the right limits are," says Dr Maelger. Again, Afton moved away from the standard DC conductivity tests to field-based assessment. "Hybrid taxis being rare, we used taxis with conventional step ATs to obtain real-world used lubricant samples. They were taken at intervals and tested for suitability in hybrid transmissions. This allowed real-world evaluation with everything present except the e-motor."

"Fluid conductivity increased only slightly overall; there was a balance between the increase from iron wear particles and the natural decrease seen in ageing fluids; and the used lubricant still had a solid all-round performance reserve."

The rapid pace of e-mobility development continues to generate questions. "Our additive chemistry has the advantage of inherent thermal stability and excellent friction characteristics, but we are never satisfied. We're always looking for new ways to assess real-world component and additive interactions," says Dr Maelger.

"Our ability to develop robust, reliable lubricant tests that predict how fluids age in service will prove every bit as important for our OEM partners as their next-generation hardware." ☺



Afton conducted a copper corrosion test, using an ATF used by a large OEM, in which the wiring was destroyed by the lubricant vapour

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Rethinking the box

Reduce driving range anxiety, increase reliability and efficiency, look for a lower TCO – that's the scope of this Dynamic Insulating System for BEV and PHEV battery packs

► There is a burning question in this industry: will customers buy the electric vehicles that OEMs are starting to mass produce?

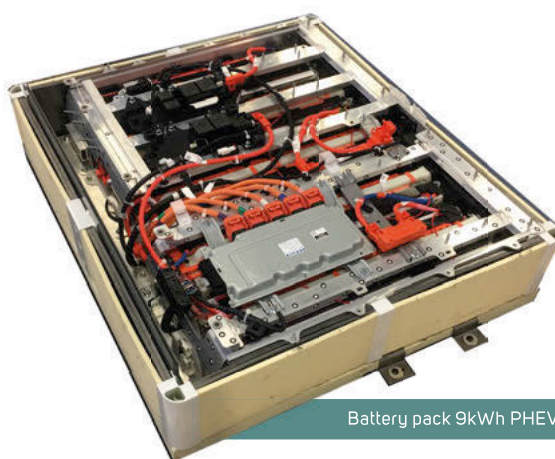
A global survey conducted by Deloitte LLP in 2018 revealed customers' biggest concerns over purchasing a BEV: driving range, the premium price and a lack of charging infrastructure. The fact is that potential BEV drivers are nervous, but so too are new customers when they look in their owner's manual for information on caring for their new car.

"If the vehicle is left standing in the cold for a long time, protect the vehicle battery from freezing. A battery will be permanently damaged by freezing," is one common warning.

"Failure to protect and care for the high-voltage battery can lead to serious damage/or a decrease of the capacity void coverage under the new vehicle limited warranty," is another.

Has the customer to assume these robustness problems, despite already paying a large sum of money for a brand-new BEV?

OEMs are looking for higher reliability and efficiency, fleet owners for better TCO and customers for peace of mind – which is where



Battery pack 9kWh PHEV



Battery pack 33kWh BEV

Hutchinson Group comes in. Recognized globally as an expert in thermal management, insulating and lightweight solutions for mobility applications, the company has launched its new DIS – Dynamic Insulating System – to address precisely these concerns.

DIS is a combination of insulating materials and formulated phase-change materials surrounding the battery pack. Its goal is to maintain the lithium-ion cells at their optimal operating temperature range: 15-35°C (59-95°F) during long periods of time (more than 12 hours) with the vehicle parked and unplugged, and with the

outside temperature ranging from -20°C-40°C (-4°- 113°F).

The innovation is in using VIP [Vacuum Insulating Panel] technology with very high insulating performances, four times better than air in a reduced volume, combined with elastomer compounds containing several phase-change materials with different melting temperatures.

These materials have been designed to preserve their thermal characteristics during the battery lifetime and to avoid any exudation or volume changes.

The company's assessment of DIS performance was done by equipping two existing battery packs, one for a BEV model (33kWh) and the other for a PHEV model (9kWh). Hutchinson Group then conducted calibrating tests with and without DIS in a climatic chamber at the Fraunhofer Institute.

The company has used these results, combined with the ageing characteristics of the cells and a complete simulation of the thermal architecture of a vehicle, to conduct simulations with the software Simcenter Amesim.

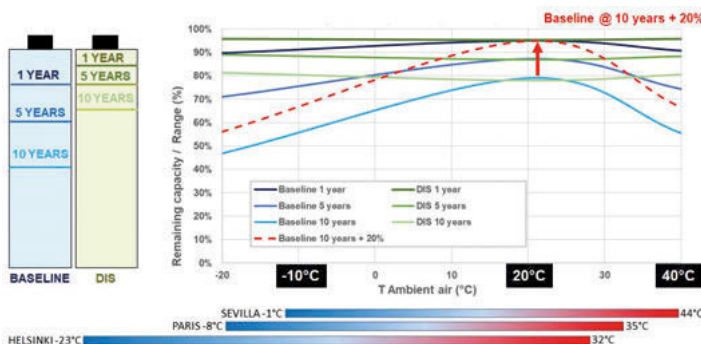
By creating a daily urban-use scenario in three different European

towns for up to 10 years, the company has introduced the cyclical and calendaring ageing of the battery cells in three different climate conditions.

The results below reveal two things. Firstly, there is a flat curve with the DIS at T+1year, which means the vehicle equipped with a DIS is much less sensitive to changes in weather conditions. The driving range is more reliable and the electric consumption is lower.

Secondly, there is a flat curve with the DIS at T+10 years, with the battery capacity remaining above 70%. This shows the potential for the DIS to preserve a higher asset value, release design constraints for the OEM, offer a better TCO to the fleet owner and above all give the customer peace of mind.

The complementary advantages Hutchinson Group can observe are promising: less charging time, better and longer vehicle operability, lower consumption and CO₂ emissions for the PHEV, better compatibility when fast charging the battery and when playing vehicle to grid strategy. ©



Ageing simulation results with and without DIS for a 33kWh battery pack

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AH SERIES



32A Wall Mount EV Charger

AW SERIES



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Power play

Utilizing phase shift correction is key for more efficient measurement results from power analysis of GaN or SiC switching devices

► Improving power efficiency of motor drive systems for electric vehicles or DC-DC power supplies means a continuous increase of switching speeds in the inverters. At the same time the inductive behavior of current sensors always causes a phase shift between voltage and current when measuring AC power at higher frequencies. Ignoring this can have a big effect on measurement results.

Thankfully, phase shift is not an issue if the frequencies in the switching device stay below 10kHz, however harmonics have to be considered as well in power analysis as high speed switching systems generate high-order harmonics. So just looking at the switching frequency is not enough.

For example, with a SiC-MOSFET switching element with a switching frequency of just 20kHz, it can be seen that phase shift has a measurable effect even at this level.

Measuring harmonics up to the 50th order of the basic switching frequency is standard for today's power analyzers. The impact of the 50th harmonics to the measurement result won't be dramatic but looking at MHz frequencies phase shift is certainly an effect to consider.

When a power analyzer is used in a high precision power measurement application, it is

typical to use sensors to measure currents. One of the reasons for this is because a direct input measurement with shunts would not be able to provide the required accuracy when measuring high currents at higher frequencies.

However, every current sensor exhibits a gradually increasing phase error in the high-frequency region due to the inductive characteristics of the sensor's magnetic core and circuitry. Furthermore, differences in the design of various sensor models cause the magnitude of this error to vary.

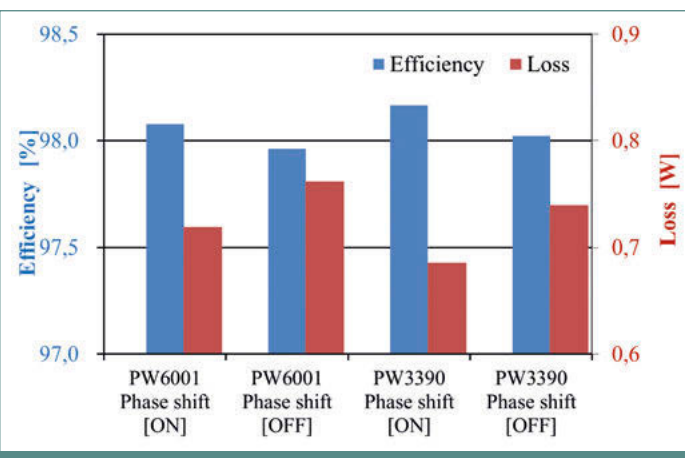
Hioki manufactures power analysis solutions offering a true phase correction feature. It designs and makes both the power analyzers as well as the sensors allowing the analyzer to detect the sensor and working based on its characteristics.

The Hioki power analyzers PW6001 and PW3390 can both use the current sensor-specific phase error information to correct this error, thereby improving phase characteristics in the high-frequency region and reducing power measurement error.

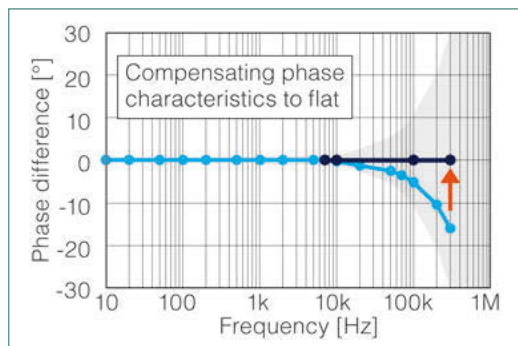
To show the effect that phase shift correction has on measurement results Hioki conducted a test and compared the same measurement once using the phase shift



Hioki's PW6001 power analyzer



A graph showing the comparison of inverter efficiency and loss



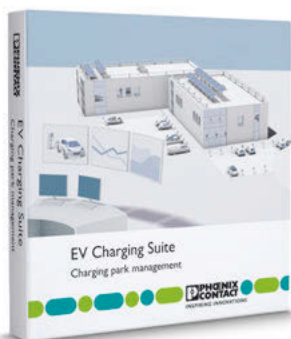
The use of a power analyzer shows phase error, with and without compensation

correction feature and once without. The test opted to use one of the most common inverter setups of one DC phase going into an inverter and three AC phases on the output side. The inverter is based on the SiC-MOSFET switching element operating at a switching frequency of just 20kHz.

Looking at the measured inverter efficiency and the loss of power in the inverter it proved the positive impact phase shift correction has on measurement results as the measured loss is lower and the measured efficiency is higher.

Utilizing phase shift correction and reducing the error caused by this physical phenomenon of phase shift increases the output of an inverter even at this low switching frequency by 0.1% to 0.15%, which is a substantial figure for inverter efficiency. It's easy to imagine the difference in efficiency results when performing the same measurement with an inverter that runs on higher switching frequencies. ☺

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Intelligent load distribution

Software for intelligent charging park management

The new EV Charging Suite software from Phoenix Contact enables you to prevent overloads and to establish the optimized and prioritized distribution of the connected loads via individual distribution keys. This guarantees the peace of mind of every charging park manager.

phoenixcontact.com/charging-software



Start charging smart

To support the surging demand of electric vehicle ownership, smarter charging technology is easing the pressure on electrical energy grids and consumer costs

▶ With a record number of electric vehicles (EVs) on the road, the landscape has never been more exciting. And, as the investment and demand for EVs continues to increase, both businesses and consumers have also begun to realize the growing cost benefits and potential benefits for the environment. While this is great news for the e-mobility movement, there are a number of challenges and concerns when it comes to the capacity of electrical grids. Luckily, alongside an increase in demand, there has also been a revolution in the smart technology, which supports e-mobility and holds the answer to making EVs more widely accessible.

Logic dictates that as more car owners chose electric powertrains, more cars will need to be charged, placing electrical grids under more pressure at certain times. NewMotion examines daily charging trends and knows that most sessions occur at around the same time of day – typically when people arrive at work and return home in the evenings. Naturally, this risks overwhelming electrical grids as well as increasing energy prices for consumers. This is where smart charging can help support the rollout of home charging solutions.

Smart charging technology can help distribute and balance available grid power, by only transmitting power to EVs when they really need it. Functionalities inherent with smart charging, such as remote start-and-stop and real-time visibility of connected charge points, enable drivers to better stagger their charging sessions. As well as reducing pressure on the grid to provide a large amount of electricity, this can also help reduce costs for consumers by using electricity at a time when demand is lower.



Top and bottom: A smartphone app provides real-time information on charge point availability, charging status, as well as remote start-and-stop functionality



Above and left: NewMotion charge card allows EV drivers access to a roaming network of more than 125,000 charge points across 35 European countries, making it easier for the move to electric



But, the benefits of smart charging extend beyond the essentials needed to support the mass adoption of EVs. Smart technology fundamentally offers a better user experience and allows charge point operators to make continuous enhancements for drivers, with all NewMotion charge points benefitting from being cloud-connected.

Smart charging also plays an important role in public charging infrastructure, an area that the UK is currently playing catch-up in. NewMotion's charge card allows drivers to access a roaming network of more than 125,000 charge points across 35 European countries. As a result, NewMotion is now at the forefront in improving public charging infrastructure in the UK,

having seen the key role that roaming continues to play in motivating the shift away from internal combustion engine vehicles.

With the NewMotion EV Charging app, drivers can access real-time information about charge point availability, speed, and price. Drivers can easily initiate start & stop charge sessions through the app and get real-time notifications on whether their favorite charge point is occupied, or when a charge point will become available again.

The company has always been an advocate of open charging networks and recently signed a letter of intent for 'roaming' alongside eight other charge point operators in the UK. This means that EV drivers only require a single charge card to access public charging stations

operated by any of the signatories – a landmark step for public charging in the country.

NewMotion has been pioneering smart charging solutions for 10 years, making it the ideal partner for companies looking for a full service partner that can help them with all their charging needs, including installation, hardware, smart charging and service. Since 2009, the company has installed more than 52,000 charge points across Europe. Over the years, the company has also partnered with a number of vehicle manufacturers and lease companies in Europe. NewMotion provides bespoke charging solutions for end users. These include partnerships with Renault and Ford and in the UK also with Arval to help the company's clients move towards carbon-free commuting. ☺

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Intelligent management

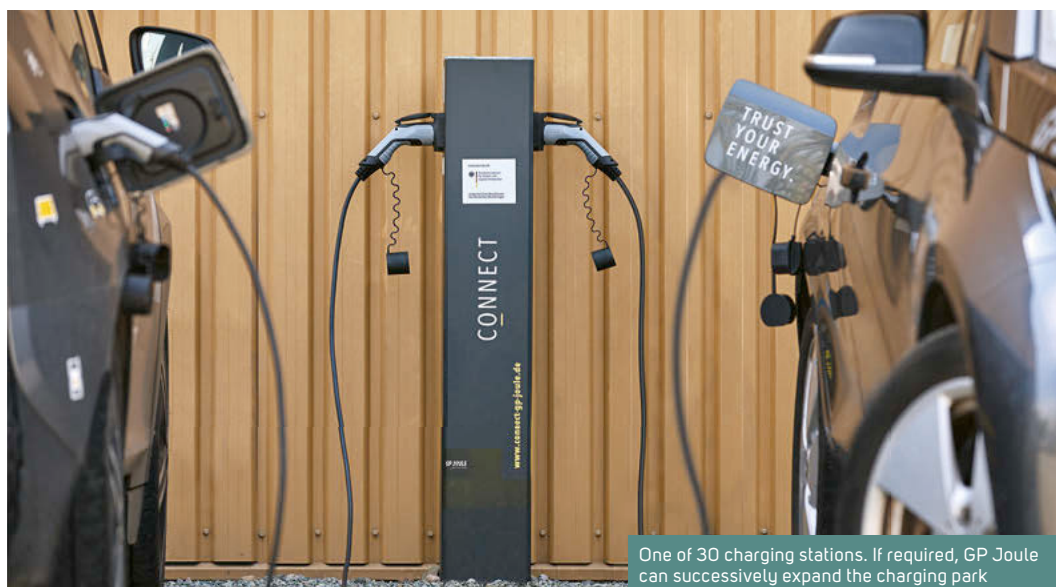
Energy management software is essential for controlling the optimum flow of electricity to support a fleet of charging EVs or large-scale consumer needs

► There is more to charging a fleet of electric vehicles than simply plugging them in, which is why newcomers to e-mobility need to plan long term and their suppliers need to develop the tools to meet their customers' needs.

Phoenix Contact E-Mobility has been working closely with energy solutions company GP Joule since 2015, among other things developing the EV Charging Suite. Today, GP Joule uses the charging management software itself, and also successfully uses it in its customer projects.

"The electrification of the fleet has far-reaching consequences," explains Jonas Elbrond, hardware developer at GP Joule, of the need to plan long term. "The demands on mobility are constantly changing – primarily due to the growth of the company and the need to integrate PV power generation or large-scale consumers into the energy management system."

Fundamental to this is the consideration of how the energy supply for charging is ensured by the existing connected load. "An energy management system is required to control the energy flow, and it can be autonomous or part of a complete building management system," says Elbrond.



One of 30 charging stations. If required, GP Joule can successively expand the charging park

"The charging controllers and the EV Charging Suite enable optimum energy management," says Piet Gömpel, software developer at GP Joule. "The suite also regulates the release for the charging process and regulates the charging current. Charging processes are actively controlled and information is sent to the electric vehicle."

Electricity from renewable energies, such as solar power, is an ideal basis for recharging electric

vehicles, so GP Joule operates its charging car park in combination with photovoltaic systems (PV systems), which provides additional connected load.

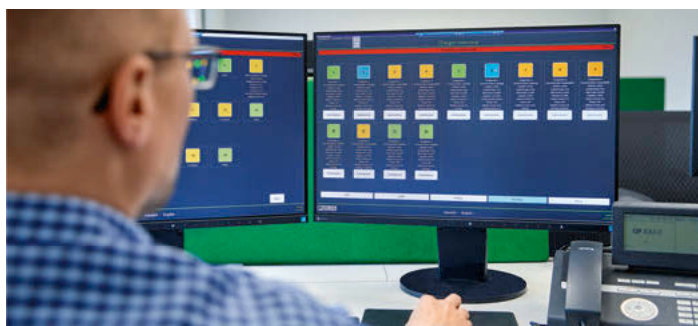
GP Joule uses the export function of the software for billing. In public areas, charging processes are billed by a third-party provider, which receives the consumption data via OCPP – the protocol is an integral part of the EV Charging Suite.

The gradual expansion of a charging park is common practice for most operators. In 2015, GP Joule started with a few relatively simple AC wall boxes. The company now operates 30 charging stations at its headquarters. Extensions are possible through a license model for 10, 30 or 50 charging points without a software update.

Just how user-friendly a scalable system is can be seen in the configuration of new charging points. With the EV Charging Suite, the parameters are easily controlled from any PC via a web browser.

The development and conception of future-oriented mobility solutions therefore go far beyond the sale of charging stations. The EV Charging Suite ensures that a range of charging applications can be implemented, and the software also takes advantage of cloud-based services where applicable to meet customer requirements.

The EV Charging Suite from Phoenix Contact is tailored to companies that want to operate anything between 10 and several dozen charging points in the future and have professional requirements for energy management, operation and safety. The intelligent and dynamic distribution of the available charging capacity, the integration of building loads or renewable energy generation as well as user prioritization cover the requirements of this target group. ☺



With the EV Charging Suite, employees have access to diagnostic details on charging status and occupation time, making management more convenient

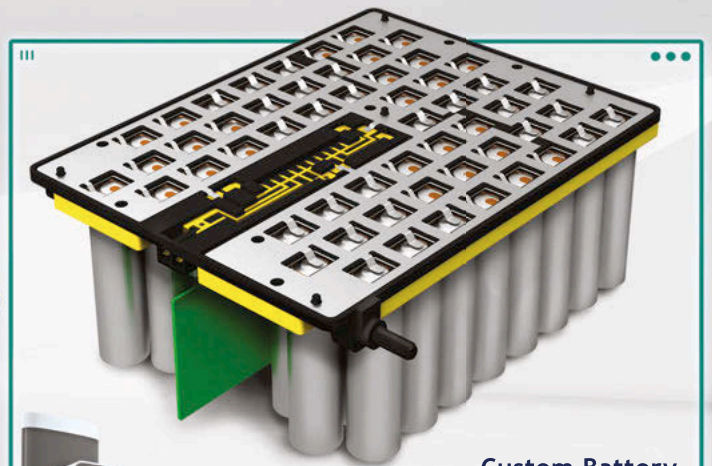
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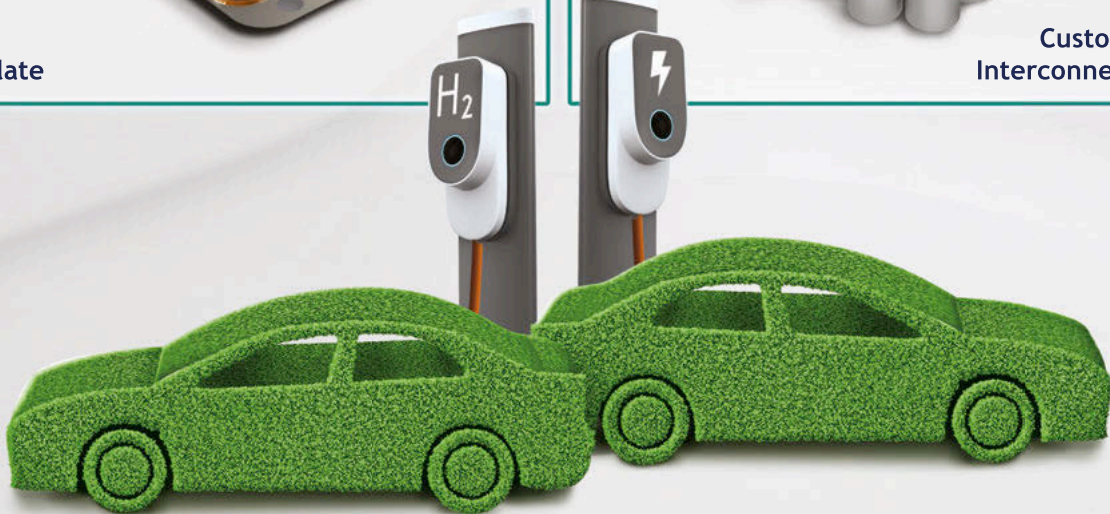
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Charging ahead

A new range of smart charging products offer efficient and flexible features for residential and commercial applications

▶ As electric vehicle charging technology is rapidly evolving environmental consideration and the desire for carbon reduction is playing an influencing role in current and future product charger design.

As a leading manufacturer in the power supply industry for ODMs and OEMs for nearly 50 years, Pihong has successfully developed a family of highly efficient EV charging products, including wall-mounted, standalone and post type AC chargers for residential or commercial use. It has also produced designs for a wall-mounted DC charger, discrete type DC charger, integrated type DC charger, and moveable DC chargers which are used for public station application, electric buses, and passenger cars.

In addition to EV chargers, Pihong also provides control and a supervisor unit (CSU) and DC charging module. Its EV chargers come with UL, CE, CNS, and ZeReady certification for the worldwide market and apply NEMA Type 3R / IP55 rating, which makes them able to operate in temperatures ranging from -30°C to +50°C, which is suitable for both indoor and outdoor applications.



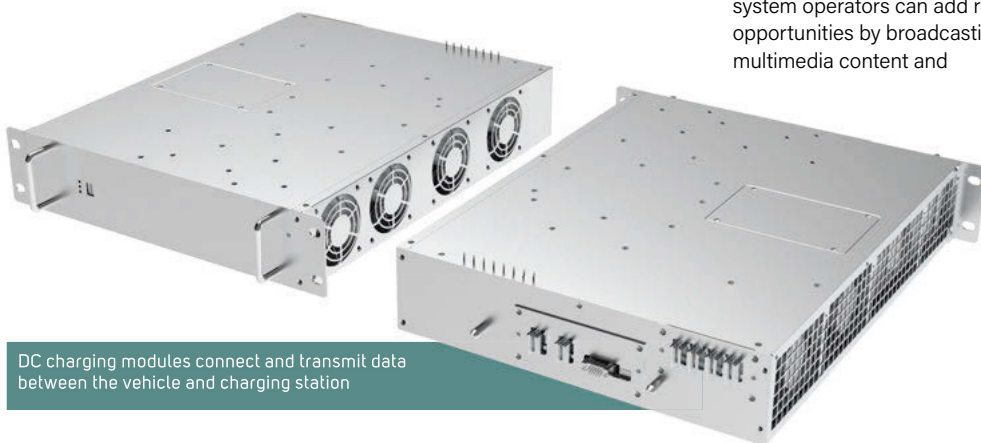
Pihong's range of DC and AC chargers boast form and function thanks to modern design and interactive user interfaces

Pihong's EV charging software solution includes both the front-end mobile app and user interface (HMI) as well as the back-end central office and cloud-based management, payment and monitoring platforms. Through the front-end mobile app, users can

search for nearby chargers, create charging appointments, and monitor charging status. System operators can monitor individual EV charger overall status and update EV charger software remotely which facilitates long-term maintenance and management. Additionally, system operators can add revenue opportunities by broadcasting multimedia content and

commercials on EV chargers. Video cameras can also remotely monitor and record its surroundings to assist with community crime prevention.

Pihong is also a member of CHARIN, CHAdeMO, and OCPP alliance, which not only keeps the company up-to-date with EV industry trends and charging standards, but it also implements new protocols and interface concepts, such as ISO1511, OCPP1.6/2.0 and more into its products. With its strong R&D design capability and solid manufacturing experience, Pihong Technology provides high quality and cost-effective hardware and software products based on specific customer needs to keep the electrification industry moving. ©



DC charging modules connect and transmit data between the vehicle and charging station

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visit: www.magupdate.co.uk/PEHV

Clean transportation

Bus operators, manufacturers and integrators face a common challenge to deliver a dependable and scalable clean power solution

► For today's and tomorrow's bus fleets, it is expected that fuel cells can address many of the dilemmas faced by diesel, natural gas and all-battery propulsion systems. It has numerous merits without compromising performance and reliability and is poised to change how people travel and utilize energy worldwide.

Compared to fossil-fuel powered internal combustion engines, a typical fuel cell system is 2-3 times more efficient, while eliminating harmful emissions. Moreover, fuel cells power electric engines, which have fewer moving parts, make less noise and require less maintenance.

Although fuel cell systems are sometimes seen as competing with battery technology, in reality, fuel cell buses are actually electric buses that use both fuel cells and minimal, lightweight batteries. By leveraging hydrogen's much higher energy density by weight (more than 3.5 times higher than batteries), fuel cell buses overcome the range, weight, performance and downtime challenges associated with battery-only offerings. As a lighter power source, hydrogen fuel cells enable greater passenger loads and longer distances, with the additional benefit of quick refueling, while battery-only buses sit idle recharging. All-battery electric buses occupy charging points significantly longer than a hydrogen refueling point, requiring a lot of space, a lot of charging points, and may require additional generation and infrastructure to accommodate the electricity demand.

Hydrogenics' fuel cell power modules are fleet-ready and proven at scale, in the field, and across a wide range of applications, from buses to trains and other heavy freight applications. Over the last



Hydrogenics' hydrogen fuel cell powered new Flyer bus

HYDROGEN'S HIGHLIGHTS

- Zero-emissions at the tailpipe
- Zero-emissions from well-to-wheel if hydrogen is generated from renewable power sources
- 500+ km (300 mile) range between fueling
- Fueling in under 10 mins
- Greater fuel economy compared to diesel and compressed natural gas
- No on-route recharging infrastructure required
- Lower weight in comparison to batteries allowing for more passenger capacity
- Reduced operational noise to improve passenger experience
- Fuel cells can be refurbished, recycled and re-used
- Consistent power delivery in cold and hot environments



15 years, the company has powered over 30 separate public and private bus initiatives around the globe, in a variety of demanding environments.

Hydrogenics' fuel cells power the world's largest fuel cell bus fleet, serving Zhangjiakou, China — home to the 2022 Winter Olympics — the current fleet provides transportation to over one million passengers a month, and is expected to exceed over 6.8 million kilometers in its first year of service, with buses running

14 hours-a-day. And this is just the start, currently with over 150 buses already in operation today, Hydrogenics has contracts to supply fuel cells to thousands of more buses over the next few years.

Hydrogenics is the only global-scale supplier producing both state-of-the-art fuel cells as well as hydrogen-generating electrolyzers. Ideally positioned as a partner and advisor for strategic hydrogen initiatives, it understands how to make hydrogen and how to use it effectively. Because most coach and intercity buses travel from bus depot to depot, a refueling station can be built on site without need for on-route infrastructure.

The ingredients to make hydrogen are simple and readily available: water and electricity. When the electricity comes from renewable sources such as solar and wind, the resulting bus transportation becomes a full-cycle, well-to-wheel zero emission solution. ☺

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Battery benchmarking

A comprehensive analysis of the battery system down to each individual cell is providing detailed results and measurements for the latest line-up of BEVs

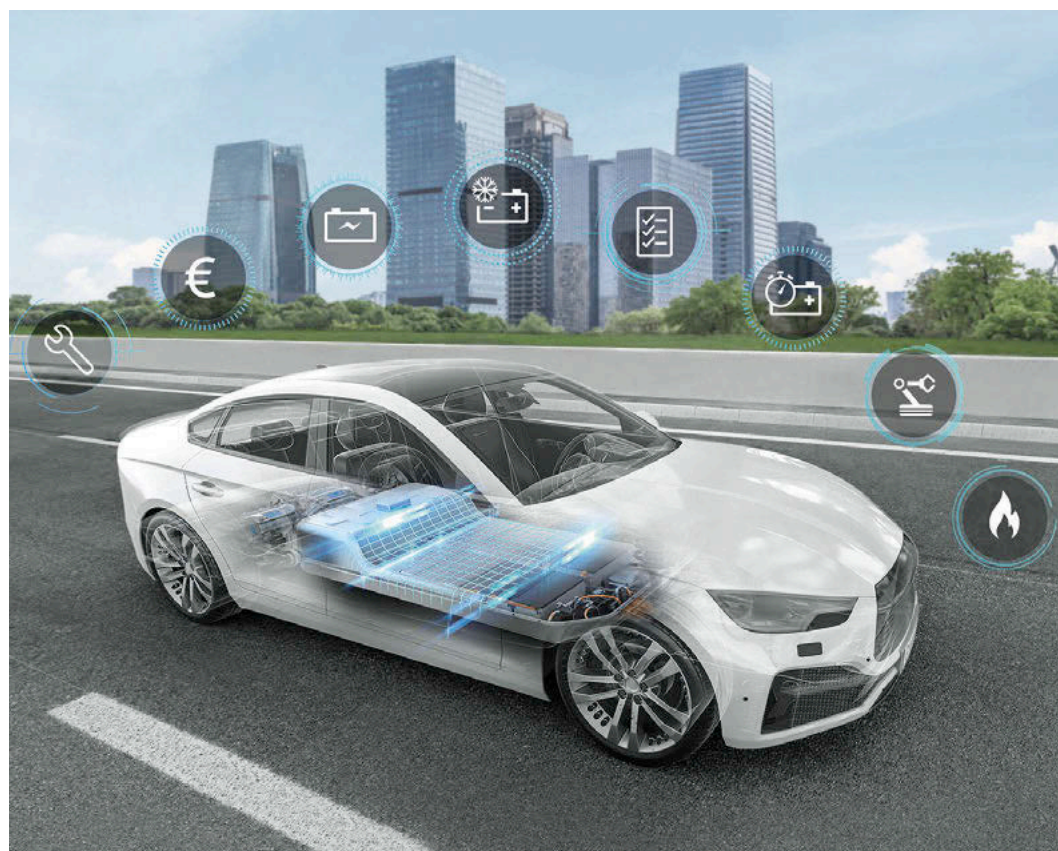
▶ New materials, technologies, processes and production methods for battery systems that have to meet customer demands for inexpensive large-scale electric mobility production, present a constant source of new challenges to development departments.

To remain ahead of the game, companies must obtain a comparative analysis of the current state of technology and the related engineering methodology. However, performing an analysis of the technical battery functions, its performance and the way in which the system is integrated into the vehicle is challenging both in terms of cost and time.

Having an independent survey of such information conducted by experts in this field can deliver major advantages. That is why AVL, experts in development, testing and simulation of powertrain systems, offers a comprehensive benchmark analysis, in which it examines and compares the competitiveness of series batteries based on more than 240 benchmark criteria.

AVL Series Battery Benchmarking is not simply a teardown of a battery it goes into extreme technical depth, offers modularity and easily accessible information. Firstly, vehicle measurements are conducted that include an analysis of the operating strategy and control systems. The battery pack is then subjected to a detailed measurement on the testbed. Based on this, AVL experts examine the thermal, electrical and mechanical subsystem. In addition to a detailed safety assessment at pack and cell level, the production process and cost structure undergo an analysis on the basis of a detailed specification list.

As well as this, the benchmarking program's extensive catalog of



AVL's Series Battery Benchmarking examines technical battery functions at a pack and cell level

criteria includes a selection of important engineering tasks such as condensate handling or EMC.

As an independent development and service provider catering to the automotive industry, AVL benchmarks up to four innovative vehicles a year to guarantee outstanding depth of high-quality information and a high level of accuracy. AVL experts regularly optimize the reports in close detail, not only where technology and development methodology are concerned but also regarding the manner in which the information

is presented to offer interested parties comparable battery attributes that also fit into an affordable budget. Customer workshops are offered, where these benchmarking results are presented and discussed by expert AVL representatives around the world.

Latest results are available from luxury SUVs such as the Audi e-tron quattro and Jaguar I-Pace as well as an affordable family vehicle from Korea – the Hyundai Kona. To particularly address solutions from a newcomer in China, AVL analyzed the NIO ES8. AVL experts test and

rate the battery systems in a variety of scenarios, and even include a detailed cost analysis. In AVL's benchmark reports it presents how well the vehicles compete with each other, and also how they compare to major rivals, for example, Tesla Model X or Tesla Model 3. In 2020 AVL is going to analyze the next big step in technology with the Porsche Taycan, and in cost optimization for the Volkswagen ID.3. ☺

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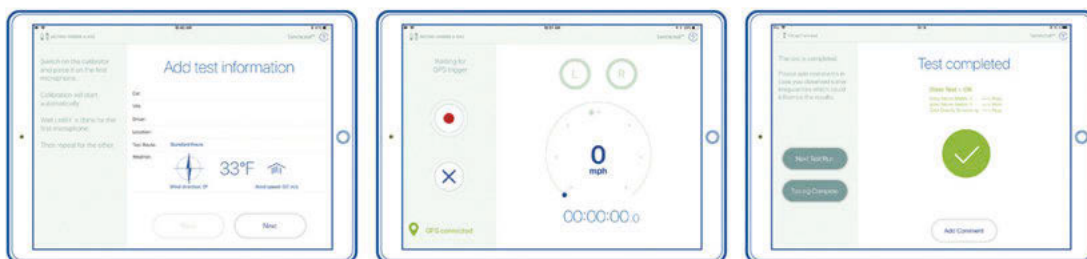
Auditing build quality

Pass/fail vehicles and identify production issues with a system developed to automatically produce and save objective data for diagnoses and problem-solving

Vehicle manufacturers face many challenges, including to ensure the build quality of their products and stay ahead of evolving customer preferences. To meet these challenges, there has been a continuous evolution of upstream in-line and end-of-line testing of components and sub-systems. The effects of those methods have been noticeable, but once off the assembly line, other issues can arise as a result of supplier parts or final assembly practices.

The traditional method of auditing vehicle production quality relies on subjective evaluations by final drive operators at the plant – the key word being ‘subjective’. To improve and drive quality indicators relating to noise, vibration and harshness (NVH), manufacturers must increase the probability that they catch and fix problems at plant level – before shipping and without adding time to current processes.

Manufacturers need a way of objectively quantifying how their vehicles perform in NVH tests as they leave the assembly line. The ability to capture, identify and fix



Example of the simplified user interface of the Sonoscout VAS including the metadata entry, measurement and results screens

issues based on a data-driven model – for example, high wind-noise vehicles – before they are delivered could significantly reduce customer complaints and expenses from post-sale repairs and warranty claims, as well as providing a means for preventing reoccurrences.

The result is a net gain in customer satisfaction, brand/customer loyalty and a reduction of production costs.

The Sonoscout Vehicle Audit System (VAS) app is a versatile and easy-to-use platform with the key tools required for proper NVH analysis built into the system, while providing a user interface that can

be limited to a simple pass/fail screen. The ability to acquire CAN data provides a range of vehicle data that can be incorporated into evaluations and trace root causes.

Sonoscout VAS codifies those tools into one automated process that needs so little input that it seamlessly integrates into existing processes, acquiring repeatable objective data and providing real-time performance results. This means there is no additional time and an absolute minimum amount of training added to existing processes – providing the required objective pass-fail results and root-cause identification capabilities.

While Sonoscout VAS was originally focused on the wind-noise performance of a vehicle at highway speed, it can be adapted to measure many other NVH attributes. The system is based on an off-the-shelf kit and the underlying software is a fully functional NVH measurement and processing system with a streamlined interface.

The GUI is streamlined with an automated interface that requires minimal interaction. The operators are not distracted by the system while testing, so the vehicle can be driven by a non-NVH-trained operator on public roads. Operator responsibilities include microphone calibration once per shift and test metadata entry before testing. Data

acquisition starts and stops based on an automated GPS trigger, and data can be auto-saved to a customer-specific site.

Once the data is acquired, Sonoscout VAS uses a data-quality screening algorithm, and the results are compared to embedded pass/fail criteria developed specifically for the customer using data from previously tested vehicles, correlated subjective feedback and the objective system output.

Stored test data can be used to add diagnostic capabilities and evaluate the effectiveness of implemented solutions. Measurement results and data derived from this, along with the test recordings and CAN data, complement subjective assessments and provide objective, traceable and actionable data.

Failed-vehicle data can be reviewed and tied to specific issues in manufacturing that can then be acted on in a single shift. At the same time, data is stored and tracked over the lifetime of a vehicle model so it can be analyzed for trends. This enables R&D, NVH, quality assurance and management teams and departments to work together to deliver better vehicles. ©



Sonoscout is easy to use for testers carrying out NVH analysis

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Faster on-board charging

Cost and space limitations make on-board charging tricky, but semiconductors make for compact and cost-efficient chargers

► In the coming years, battery electric (BEV) and plug-in hybrid (PHEV) vehicles will shape the cityscape much more than they do today. Both use lithium-ion battery packs with a capacity of 40kWh to 80kWh (BEV) or around 10kWh (PHEV). With BEVs, charging from an external source is a basic requirement; with PHEVs, it is in addition to recuperating kinetic energy, for example during braking.

There are three basic charging scenarios, which each have different charging power requirements.

Main Harbor Charging refers to charging at locations where the vehicle is kept for a long duration, typically at home and at work. Charging time plays a minor role, so the available installation is used and provides power levels up to 1.9kW (120V, 16A, 'AC level-1') in the US or 3.6kW (230V, 16A) in the EU.

To charge a battery with a capacity greater than 40kWh overnight or during working hours, the charger will require an output power of 11kW or more, which necessitates three-phase power inputs. Main Harbor Charging is where the on-board charger (OBC) in the car comes into play, converting AC from the external power source to DC to charge the battery.

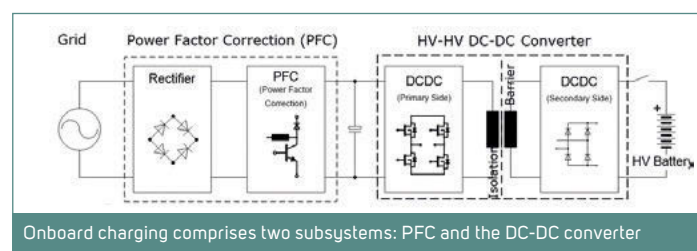
Destination Charging occurs at locations such as car parks at supermarkets and shopping centers. It lasts for a shorter time and is usually used to recharge the battery sufficiently, rather than fully. This requires a higher charging power and, today, most charging stations are still based on AC level-2, which reaches up to 43kW of charging power. AC-DC conversion is carried out by the vehicle's onboard charger, which also limits charging speed, depending on its maximum power. Therefore, the trends go to DC

fast-charging stations that integrate the power conversion, enabling charging at 50kW and more.

With Range Extension Charging, the battery is charged in the shortest possible time to enable longer distances for BEVs. The respective DC fast-charging stations feature today power in the range of 50kW to 120kW. For the near future up to 350kW are planned.

The OBC combines the conversion from AC to DC voltage and the control of the battery charging, which means it needs to ensure compatibility with single and three-phase power networks in addition to the various required communication protocols. At the same time, active power factor, isolation and EMC requirements need to be met in the input side, as well as supplying the proper charging current and voltage on the output side.

An on-board charging system will consist of two subsystems:



Onboard charging comprises two subsystems: PFC and the DC-DC converter

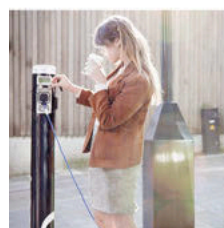
the active power factor correction stage (PFC) and the DC-DC voltage converter (DC-DC). The PFC stage secures an active power factor of >0.9 on the line side, implements the rectification of the AC line voltage to an intermediate DC circuit voltage and communicates with the charging station.

The DC-DC converter controls the battery charging current and separates the mains from the battery side by galvanic isolation.



Main Harbor Charging

- > where: at home or at work
- > how often: daily
- > how long: more than 3 hours
- > premis for buying an electric or plug-in hybrid vehicle



Destination Charging

- > where: super market, shopping mall, cinema, restaurant, etc.
- > how often: one to two times per week
- > how long: less than 3 hours
- > more convenience for owners of electric or plug-in hybrid vehicles



Range Extension Charging

- > where: along highways and long-distance travel routes
- > how often: highly depending on use case
- > how long: less than 30 minutes
- > premis für for buying an electric vehicle

The three basic charging scenarios for BEVs and PHEVs

in turn affects power density, cost and efficiency.

Each of the circuit topologies mentioned requires different types of semiconductors. For example, the high switching frequency of an LLC converter (up to 500 kHz) means MOSFETs are the best choice.

A totem pole PFC operating in continuous conduction mode requires fast switching IGBTs due to hard switching of the devices, while silicon carbide (SiC) MOSFETs and diodes can increase efficiency. Infineon Technologies offers the full range of power semiconductors specifically designed for OBC systems as well as suitable driver ICs and microcontrollers. ☺

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Well connected

Robust, customizable battery interconnect systems streamline design and manufacturing of battery modules

► The accelerating growth of electric-powered vehicles puts pressure on vehicle and battery makers to deliver more robust, compact and powerful battery modules. Battery module designs vary widely by manufacturer and specific end application, and with advanced battery modules for EVs and public transportation containing thousands of individual cells, it increases complexity of the system.

To meet growing industry demands, battery design engineers are seeking out more robust and adaptable interconnect technologies for the increasing variety of battery module sizes and designs.

Cell-PLX technology, created by Interplex, addresses this need with customized battery interconnect systems tailor-made for specific application requirements. It is suitable for use with cylindrical, prismatic or pouch battery cells, it supports various current densities and cell array configurations, with robust packaging formats to uphold battery module durability in high-vibration environments.

Interplex's design expertise and vertically integrated in-house production can help businesses accelerate their battery interconnect system's time-to-market. Cell-PLX provides maximum configurability for different form factors, sizes and performance requirements, with a wide range of material options and plating finishes.

Cell-PLX's high-precision current collectors maintain the tight tolerances needed for reliable and long-lasting performance. Thicknesses can be customized to match current density requirements. Positive and negative cell

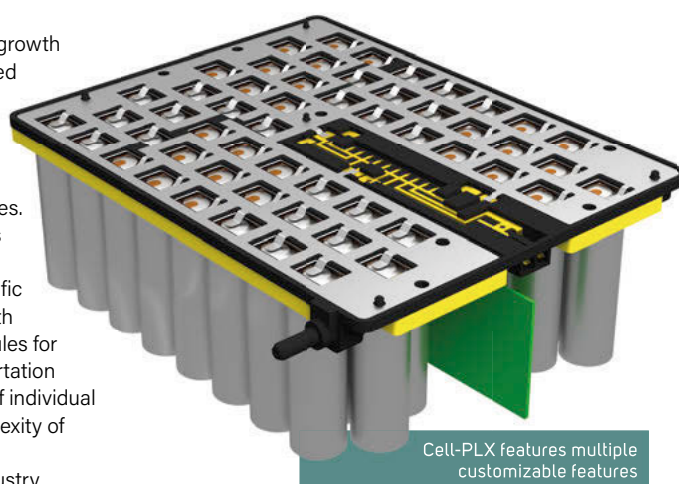
connection terminals can be formed down to cell level for laser welding or wire bonding to the battery cells.

In applications that require positive and negative terminals to be on the same side of the battery cell, Cell-PLX can be configured with two current collectors separated by a dielectric layer, or a single thicker current collector.

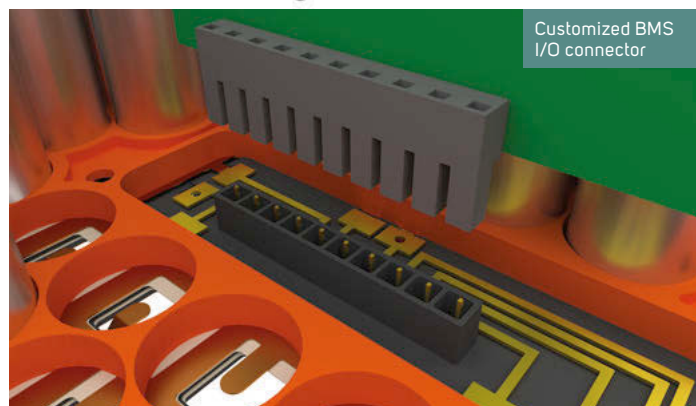
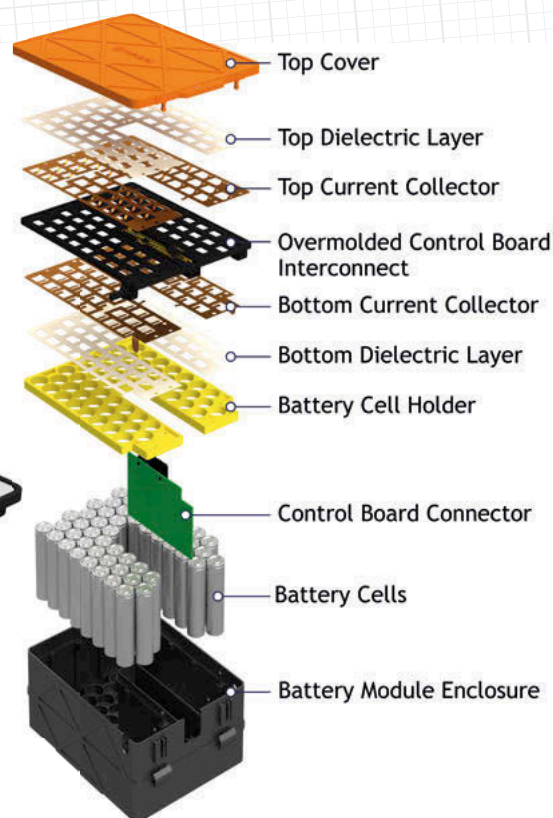
Using advanced high-speed manufacturing processes, the terminals can be thinner than the current collector itself. This assures ease of welding to the battery cells while maintaining strength and structural integrity across the entire current collector. Customized designs also enable optimal positioning of the terminals for mating with the cells.

This, combined with options for configurable and secure battery cell holders, improves connection quality and robustness. Cell holders also have the ability to incorporate the bottom dielectric layer, which can then be attached to adjacent layers by heat staking instead of pressure-sensitive and thermal activated adhesives.

Cell-PLX technology also allows integration of custom-designed



Cell-PLX features multiple customizable features



Customized BMS I/O connector

overmolded lead frames to connect Battery Management System (BMS) control boards to the current collectors. Various connection options between battery modules are possible, such as nut/bolt, pin/socket and other custom configurations.

Other interconnect design options allow for passive and active component placement for safety and cell monitoring such as fuses, thermistors, most positive and negative interconnects, cell holder designs, signal interconnects or harnesses/circuits connecting to the control board.

To cater to the growing range of advanced battery applications, the

underlying interconnect implementation technologies must deliver both durability and adaptability for application-specific requirements. The customizability of Cell-PLX battery interconnect systems enables this technology to be applied to an extensive range of applications, such as aerospace (electrification of civil aviation); automotive (EVs); commercial transportation; maritime vessels; personal mobility; energy (wind and solar energy storage). ☺

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ISO 26262 compliance

Taking advantage of complex regulation can guarantee high standards of functional safety for EV electronics and software, as well as simplifying system safety certification

► Engineering, quality, and sales departments in every organization all have different objectives that can often cause conflict. Whether it's the importance of delivery of products to meet budget, the importance on quality, or the need for innovation – the complex ISO 26262 standard presents a solution to resolve this eternal power struggle. However, in order to make it effective, it is necessary that all parties must acknowledge the importance of the standard and work as a team.

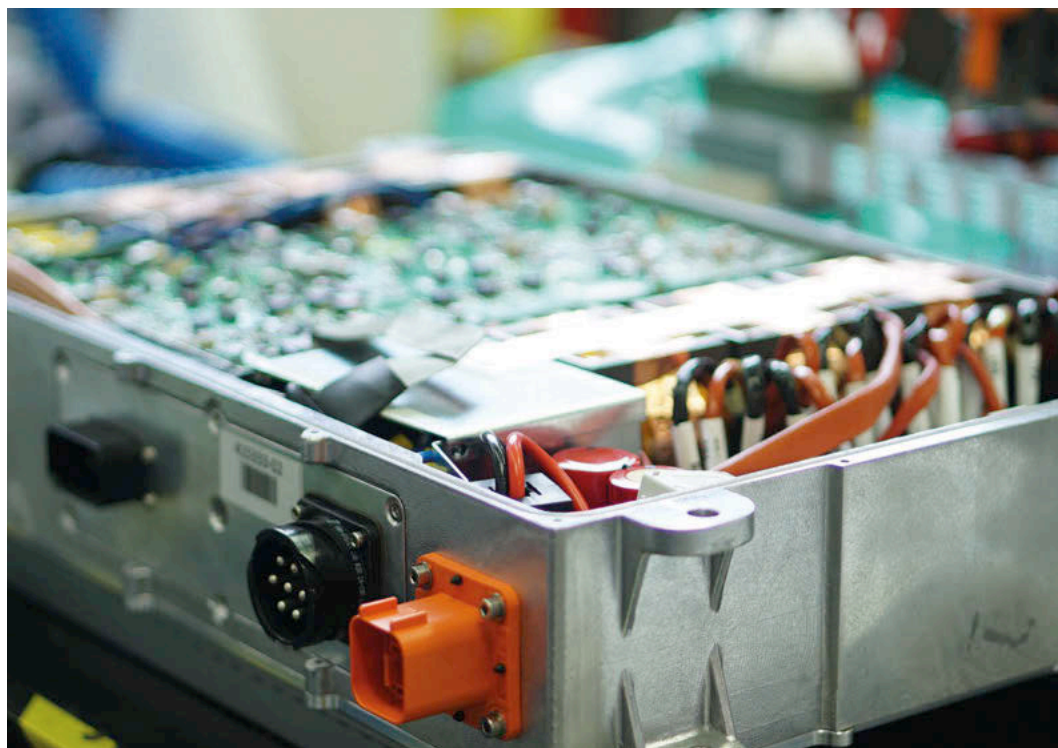
ISO 26262 was defined in 2011 by the International Standards Organization (ISO) as an international standard for the functional safety of electrical and/or electronic systems in the automotive sector. This is an adaptation of the IEC 61508 functional safety standard and arrived just in time for the rapid development and adoption of electronics and software in electric, hybrid and self-driving vehicles.

It is a risk-based safety standard, where the main objective is to assess risks and define measures to mitigate the effects to avoid or control catastrophic failures. Recent IT integration in all technological sectors and complex computer-based control systems for vehicles comes at the cost of a higher possibility of errors in extended algorithms used for software.

With this in mind, the presence of such a higher risk in a critical subsystem could be suppressed under the compliance of ISO 26262, thus resulting in foolproof safety.

ISO 26262 has a Product Life cycle Management (PLM) approach that starts from product conceptualization through to design, development, operation, service, and decommission at end of life.

Specific to automotive systems and regarding passenger and driver



A process using ISO 26262/IEC 61508 hardware and software guidelines can prevent dangerous system faults

safety, the standard has four Automotive Safety Integrity Levels (ASILs) – A, B, C, and D. The process of ASIL assessment starts from the product development and looks at the fundamental question of what will happen to the occupants of a vehicle, and other road users, if a failure occurs.

The risk evaluation to mitigate the failure is based on a combination of the probability of exposure, the controllability by a driver, and the possible severity (ASIL criteria) if a critical event occurs.

The answer to this evaluation determines the ASIL level. For instance, level D involves the most safety critical processes and requires most severe testing. As a result, all hardware and software

must be compliant with ISO 26262 and needs to be qualified through extensive testing.

The testing phase is comprehensive and an arduous process, but the outcome far outweighs the costs of the time spent extensively to accomplish the goal. In addition, a failure found in the field can be ten-times more expensive to go back and rectify, than one found during the development stage.

Although many issues can be resolved or mitigated by using pre-qualified modules where applicable, however, it must be accompanied by the documentation and a supplier that can support the criteria to get through the qualification process.

EDN Group is committed to design and develop a rigid process, using an ISO 26262/IEC 61508 hardware, and software development guidelines to support detection and prevention of dangerous failures resulting from systematic or random hardware faults. This is supported by design resources to help solve the most complex safety design challenges.

ISO 26262 provides a set of common rules that engineers, sales, and quality teams can all adhere with less subjectivity and more confidence in the final product's quality and safety. ©

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High voltage connectivity

An innovative cable system offers electric vehicles with a safe and reliable connection for challenging applications

► According to a European Commission report, heavy-duty vehicles are responsible for carrying 75% of all land-based freight. In doing so, they are liable for around a quarter of CO₂ emissions from road transport in the EU and account for around 5% of Europe's greenhouse gas emissions.

These figures represent why the automotive market is evolving towards electric vehicles. Delivering high voltage solutions to EV customers worldwide, Huber+Suhner has many years of experience in addressing the challenges of the EV market and has recently launched a new cable system called the Radox EV-C.

Depending on their purpose, heavy-duty vehicles such as trucks, construction and special vehicles require a full range of mechanical and electrical solutions to transmit and distribute power. Therefore, any high voltage connection must be safe and reliable, as well as suitable for the most demanding applications, including high temperatures, current peaks and extreme loads.

Historically, vehicle manufacturers and their suppliers have sourced cables, connectors and high voltage distribution units separately from different suppliers and then assembled them together, which leads to further challenges such as compatibility.

Leveraging its experience, Huber+Suhner is now revolutionizing this process by offering an end-to-end interconnected system including high voltage cables, its High Voltage Distribution Unit (HVDU) and the latest innovation, Radox EV-C.

Designed to provide the EV industry with a superior solution, the Radox EV-C is an innovative cable



High voltage connections must be safe, reliable, and rugged



Heavy-duty vehicles require a range of solutions to transmit and distribute power

system that provides hybrid and electric vehicles with a safe and reliable connection for even the most challenging applications.

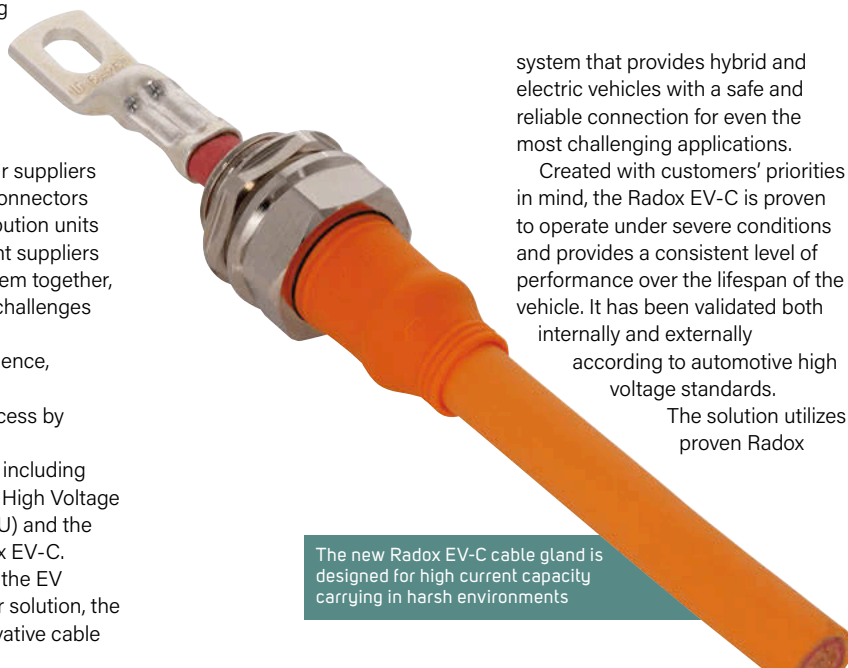
Created with customers' priorities in mind, the Radox EV-C is proven to operate under severe conditions and provides a consistent level of performance over the lifespan of the vehicle. It has been validated both internally and externally according to automotive high voltage standards.

The solution utilizes proven Radox

technology from Huber+Suhner, which uses an electron beam crosslinking process for the cables. This process achieves notable improvements in the thermal, mechanical and chemical properties of the cable insulation. Merging this cable technology with the new EV-C gland provides a state-of-the-art connectivity solution for demanding heavy duty applications.

Offered in seven sizes, ranging from 16mm to 120mm² in five main variants, the solution provides wide configuration flexibility for customers' specific needs.

With the number of electric vehicles on the road increasing, as a result of both regulatory actions and customer preference for sustainable options, the availability of innovative solutions such as the Huber+Suhner Radox EV-C helps ensure safe and reliable operation now and in the future. ©



The new Radox EV-C cable gland is designed for high current capacity carrying in harsh environments

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Lightweight 3-way valve for fluid control

► Engineers in the electric and hybrid vehicle space are under pressure to develop systems that help meet the goal of greater distance per charge without sacrificing performance or style in the vehicle design. Advanced thermal management and component efficiency are great starting points for meeting these goals.

TLX Technologies recently introduced its newest innovation in fluid control for vehicle applications. This valve has been designed to electronically control coolant from one pump to two cooling loops in a vehicle's system. Utilizing a solenoid operated pilot valve to control a pressure-operated main control valve allows 3-position operation with minimal pressure drop. Peak and hold or latching technology can be integrated for optimization and reduction of power consumption. Designed for high flow

applications with 1 inch hose fittings for both the inlet and outlet ports, this patent pending valve's flow characteristics can be customized. The lightweight and durable 3-way fluid control valve provides the performance and flexibility needed to make it a great option for many electric and hybrid vehicle applications.

TLX Technologies uses proportional, high-speed, high temperature, and latching solenoid and valve technologies to custom design electromagnetic products. Our engineering team supports OEM innovation with solutions that meet challenging requirements in a wide range of applications.

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High-voltage contactors series

► TDK high-voltage contactors series HVC is made to meet the requirements for high-voltage DC emergency disconnection applications in electric cars, trucks, busses, energy storage and DC fast chargers. The

newly updated HVC series is now available with an increased voltage of 1,000V and with 200A, 300A or 500A operating current. It comes with decreased contact resistance and integrated coil termination.

The gas-filled ceramic arc-chamber safely and quickly extinguishes the current during breaking ensuring excellent extinguishing characteristics, while the make and break performance under load is increased. For bi-polar design allowing charging and dis-charging at the same time the single-coil remains the best choice.

For even higher load-cycle performance, a dual-coil option has been added, serving as economizer technology. Instead of a single coil, this version of HVC features a pick-up and a holding coil. During the first 120ms current consumption is high (2A at 24V) to increase the make ability and, correspondingly, the break ability.

After 120ms, the current consumption decreases to 0.1A at 24V. Only the holding coil is used during HVC remains closed. With 4W power consumption from the holding coil, the coil-power was decreased by more than 30% compared to the single coil version.



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High performing, compact contactor

► A contactor is a small, yet important component in an electric vehicle to switch power to loads supplied by the battery.

TE Connectivity's new Kilovac EV600 contactors carry 20% more current than legacy alternatives.

Kilovac electric vehicle contactors are designed to offer the highest performance, the smallest and lightest weight sealed high voltage contactors in the industry. With current carrying capability of up to 600A and power switching up to 200kW, they are used in a variety of industrial, marine, automotive, and commercial applications. Primarily designed to switch resistive loads, they can be used in a variety of circuit applications bearing in mind a few important considerations. This application focuses on a few of the more common circuit configurations, and what to consider when selecting, installing and using the contactors.

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Vehicle control unit and charge management in a single controller

► Vehicle control units (VCU) from Pi Innovo, the OpenECU M560 and M580 are designed to eliminate the need for using a separate electric vehicle charge controller (EVCC) and a separate VCU in electric vehicles.

OpenECU M560 and M580 offer hardware and software capabilities to integrate charge management and supervisory control in a single electronic control unit (ECU).

OpenECU M560 and M580 are based on the proven OpenECU Functional Safety (OpenECU-FS) platform, through the combination of hardware, platform software, and Simulink-based application software. Both products have Powerline Communication (PLC) transceivers providing capability for AC charging and DC fast charging.

The combined charging system (CCS) software package enables charge management supporting SAE J1772 and

DIN 70121 standards. Functionalities include, but are not limited to, input signal processing, control pilot signaling, and sequence controller.

The electric vehicle supervisory control strategy package allows customers to accelerate the development of control systems for electric vehicle control. The OpenECU platform allows customers to rapidly deploy supervisory control and CCS controls from prototyping to production.

By using the OpenECU controllers M560 or M580 users can integrate and consolidate CCS with supervisory control realizing significant cost and space savings for electric or hybrid vehicle programs.

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DC MEMS for any situation

► PCB Piezotronics has launched a new family of DC MEMS F series accelerometers for low-frequency measurements down to 0Hz (static or DC acceleration).

This new variable capacitive, gas damped MEMS family includes single-axis and triaxial DC single-ended accelerometers, as well as single-axis DC differential accelerometers. These sensors are designed for uniform, repeatable performance and offer high overload protection. The new series uses the latest commercially available MEMS technology and comes in six models with measurement ranges of ± 2 , 10, 30, 50, 100 and 200g. They are PCB's most refined DC accelerometers to date, using the latest MEMS technology with broad frequency range, low noise, low offset voltage, excellent broadband resolution and true-differential output. The entire family exhibits a high overload shock capability ($\pm 3,000$ or 5,000g) along with a wide operating temperature range of -54°C to 121°C (-65°F to 250°F).

Electrically, these new units offer a single-ended or differential output signal with power, signal and ground leads for each channel. Supply voltage regulation permits operation from +5V DC to +32V DC, enabling their use with many data acquisition systems, and the low-noise, low-impedance output signal may be transmitted over long cable lengths without degradation.

These DC response accelerometers were specifically designed to help automotive test engineers during low-frequency vibration testing. They are well suited for applications such as ride and handling assessments, drive-ability and shift quality work, suspension development, NVH testing, road load data acquisition, brake deceleration compliance certification, durability testing of vehicle radiators and air coolers, roll stiffness/static rollover

threshold evaluations, vehicle and component test chamber instrumentation, and multi-axis motion testing platforms.



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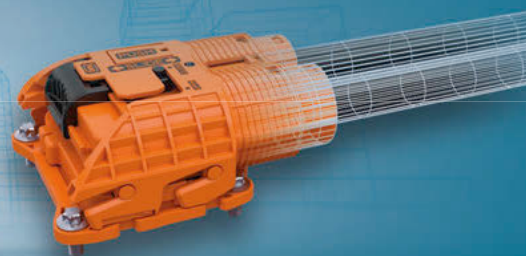
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1500v battery pack testing

► Bitrode, recently introduced the FTF-HV series high voltage pack testing system for the laboratory battery pack testing market.

This new member of the FTF high power pack testing system family is capable of 1,500V and 600A per channel with a maximum power capability of 450kW per channel. The FTF-HV is available in single channel and two channels per cabinet.

The IGBT-based design has a power factor of 0.99, is 92% efficient with power being fully regenerative back to the grid, 0.05% current accuracy, and has 30m/sec risetime (10% to 90%) with zero overshoot. Charge/discharge switching time is zero seconds and data acquisition rates are optionable as low as 1m/sec. The FTF-HV is controlled by the same VisualCN software that is used on all Bitrode testers, from the MCV series all the way to the FTF series.

"The journey to create these 1500-volt testers has not been easy, but we now have two fully

tested units in our R&D testing lab that we would proudly present to any customer wishing to come to St Louis to see them in action" states Craig Brunk, VP of sales and marketing, "this is an important achievement for Bitrode and for battery manufacturers wishing to design past the current

1,200v high voltage packs for use in personal vehicle and mass transit markets."

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Keeping EV batteries and drivetrains safe

► Today's electrical vehicle batteries and associated drive trains are complex, high-voltage systems that need to be constantly monitored for insulation breakdowns and failures. High-capacity circuits shorting out to a vehicle's frame can pose unwanted fire risks and hazardous touch potentials for unsuspecting occupants, operators, or maintenance personnel.

Bender's IMI (Isolation Monitoring Interrupter) ensures accurate ohmic readings across the entire drive spectrum from standstill, full acceleration and under re-generation conditions. Bender also provides similar safety circuits for EVSE (electrical vehicle supply equipment). Here, milliamp leakage detection circuits, also known as CCID (charge current interrupting device) are being provided as an integral safety device

into Level 1 chargers as well as Level 2 charging stations and wall boxes. Demanding Level 3 DC fast charger applications in the multiple hundred KW range are being protected by IMIs looking for insulation breakdowns, similar to the EV application. For Chademo circuits, the IsoCha425 IMI reliably employs active and passive measuring principles to safely interrupt when a ground fault occurs.

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Testing solutions for the electrical test center

►► Critt M2A's electrical department is equipped with 96 test channels for battery cells and five battery module tests systems in climatic environment to characterize electrical and thermal behavior of batteries used in automotive, motorsport, railway and aeronautic industries. Critt M2A can characterize the complete EV battery pack thanks to six climatic test benches from 14 to 19m³ and up to 750kW. These solutions are equipped with water and air cooling systems and all appropriated safety systems in case of battery failure.

Critt M2A is also equipped with a four-wheel drive test bench to perform tests on electric, hybrid or ICE vehicles/powertrains. This enables the testing and validation of partial or entire hybrid powertrains. All electrical and mechanical components can be tested in a realistic emulated environment in an early development phase.

CrittM2A has recently been equipped with battery simulators (AVL E-storage) to perform battery characterization tests (32kW / 0-60V / ± 600A). This equipment

offers measurement and control accuracy with maximum dynamic performance, to fulfill the specific needs of customers.

It can use both emulator modes to simulate the battery of a consumer, and tester battery to characterize its performance. It can also be used on engine test benches to perform tests on hybrid engines.

With these e-storages, Critt M2A completes its range of turbocharger tests including electric compressor, recovery system and turbo compounds (including turbo and electric engine).



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Modular EV battery pack test laboratory

►► Proventia offers modular EV battery pack test laboratories with climatic features optimized for customer's technical requirements and preferences.

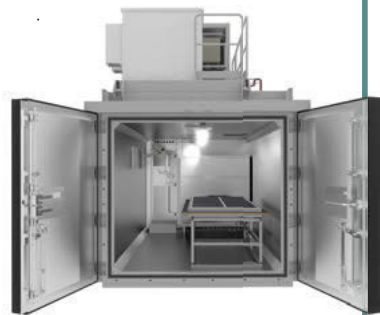
Battery cyclers, test equipment and automation systems can be selected from the widest range of key component suppliers. Different designs and layouts provide flexibility for building up the test capacity almost anywhere, both indoors and outdoors. Test facility can be easily expanded in phases.

Proventia's environmental EV battery test chamber is one of the largest on the market, accommodating full-size battery packs and offering enough space to run tests with several packs simultaneously. Modular test laboratories are easy to transport and quick to deploy, and they integrate with the existing facility arrangement.

As a free system integrator, Proventia works directly with the key component industry, which enables deliveries with

combinations of test equipment and automation systems.

Proventia is a turnkey supplier, who provides CE marked and complete EV battery pack test laboratories that comply with the EU Machinery Directive and health and safety regulations. All the equipment, every detail and foreseeable preparations for future upgrades are brought into the modular design, completed at the factory and tested to ensure that the assembly on site is as quick as possible.



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Big on power battery packs and modules

►► In mid-2019, BorgWarner formed a joint venture with Romeo Power Technology, a technology-leading supplier of battery packs and modules. This strategic step gives BorgWarner the ability to provide its customers with the relevant products, and this in-turn enables the company to manage the overall efficiency of the entire electric vehicle propulsion system – from charging, to moving the wheels.

The addition of battery packs and modules as the last puzzle piece energizing BorgWarner's existing product portfolio for hybrid and electric vehicles, which features power electronics, onboard battery chargers, eAxle iDMs, electric motors, high-voltage battery heaters and much more besides.

BorgWarner's compact battery packs and modules include intelligent battery management systems with proprietary algorithms and industry-leading energy

densities for enhanced performance and cycle life. They also feature proprietary thermal engineering for active and passive cooling. The scalable design of the technology allows faster time-to-market for customers with tailor-made modules.

The battery module is comparatively light at 48kg, has a capacity of 10kW hours and is available as both a 48V and a high-voltage version. According to BorgWarner's specifications, the battery pack survives over 2,000 charging cycles and 10 years of use. With this innovative solution, the company provides its customers not only with the longest possible pure electric driving range but also with extraordinarily fast charging times.



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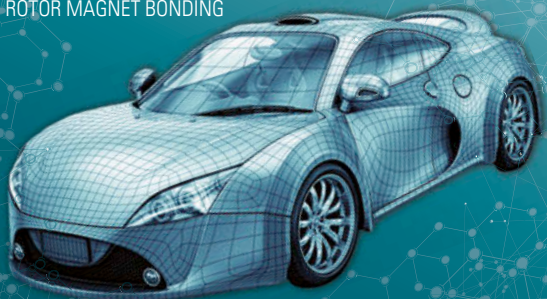
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Considerations for Electric Vehicle On-Road Evaluations

►► Electric vehicles can benefit from on-road evaluations to assess interactions with charging stations and power grids. This provides data on interoperability and power quality to be used for benchmarking or product design/development. The process may seem straightforward, but there are many considerations to make. These include what you trying to answer and what are your priorities? Defining the goal in advance is critical to building and implementing a successful test plan.

It is important to ensure drivers are properly trained for both driving and data collection. This is especially important in foreign markets and with prototype or modified vehicles. There is a need for them to understand terrain, elevation changes and traffic patterns to plan the best route for the data required, and

also knowing charging station locations, public accessibility, and functionality.

They should account for driver shifts, holidays and potential adverse weather. They will have to securely upload test data every day, and know whether they have access to vehicle service if repairs are needed.

On-road programs often present logistical challenges unrelated to the technical aspects of testing and driving.

Therefore, working with an experienced team to build a plan that considers all relevant factors is important. Intertek offers on-road assessment solutions, taking advantage of a global network of labs dedicated to electric vehicle testing. The company's on-road testing services are fully complimented by in-lab evaluations to provide end-to-end peace of mind via controlled and real-world environments.



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Bi-directional high power test bench energy system

►► Reliable and powerful test equipment along the whole supply chain from R&D to end of line test is mandatory for today's automotive industry. Especially verification tests in the area of drivetrain and battery applications for HEV and EV require a safe to operate test equipment with high reproducibility over a wide range.

The new Heinzinger ERS-BIC is a high power and high dynamic bidirectional system, with active energy recovery to the grid specially designed for such applications.

The Heinzinger ERS-BIC perfectly supports battery simulation for power electronic and electric motor tests as well as tests for hybrid and drive batteries. With a voltage and current range up to 1200VDC/2400A and range of power stages up to $\pm 1200\text{KW}$ (Master-/Slave) nearly every electric powertrain or fuel-cell application can be supported.

The ERS-BIC is available with one, two or four-channels. To increase the maximum output current and power it is possible to connect the output channels in parallel.

A safe and efficient operation of the regenerative power supply is guaranteed by electrical isolation between mains grid and DC-side via high power water cooled isolation transformers. A broad range of options in combination with the Heinzinger engineering and after sales support complete the offered service.



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Parylene increases reliability of electric and hybrid vehicle electronics

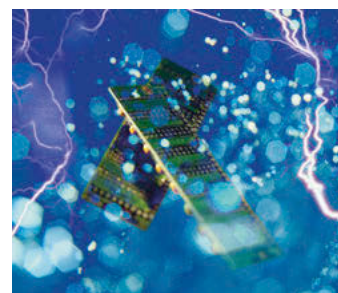
►► Ultra-thin and lightweight, Parylene conformal coatings offer excellent moisture, chemical and dielectric barrier capabilities to protect electronics used in electric and hybrid vehicle technologies.

The coatings are also able to offer superior thermal and UV stability and, for elastomeric components, a low coefficient of friction.

Parylene coatings are applied as a vapor, so there is no liquid phase in the coating process. As a result, there are no meniscus, pooling or bridging effects. The molecular growth of Parylene not only ensures an even, ultra-thin, lightweight conformal coating, it also enables the coating to penetrate into every crevice, providing complete encapsulation of the substrate. Parylenes provide a level of protection that is unmatched by many conformal coating materials.

Manufacturers in the transportation industry have long relied upon various methods to protect electronic systems, but newer, more advanced electronics require advanced levels of protection that must be lightweight, achievable on any component size, survive harsh environments, and cannot interfere with the sending or receipt of control signals. Parylene conformal coatings are able to meet these requirements.

RoHS and REACH compliant, Parylenes provide an innovative solution for protecting sensors, circuit boards, MEMS, LEDs, elastomers and other surfaces and components that require reliable, long-life performance in harsh and challenging automotive environments.



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Dispensing solutions for battery manufacturing

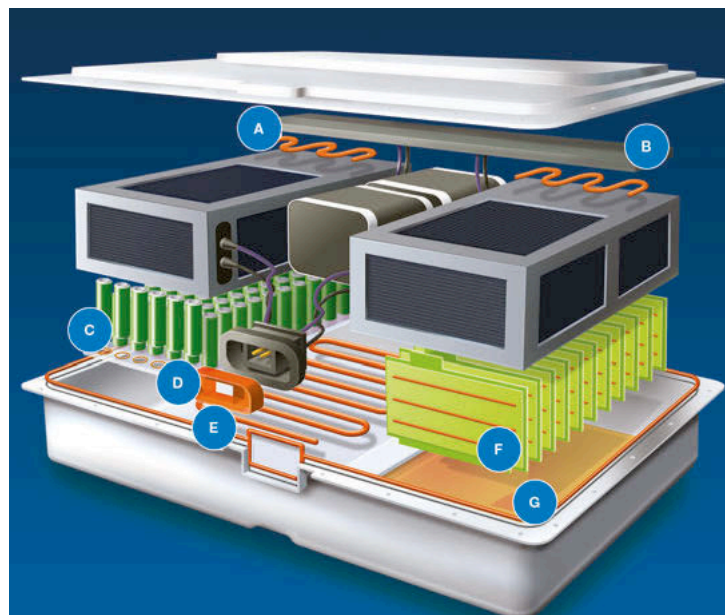
►► Battery production incorporates many diverse applications, such as separator manufacturing, anode and cathode bonding, or applying abrasive thermal management materials. To enable more efficient production, automated dispensing solutions for 1K or 2K sealant and adhesive materials are required.

Battery cell bonding of cylindrical battery cells is often challenged by production speed and location accuracy, as hundreds of cell pockets must be dispensed into, which adds robot complexity in small timeframes. Additionally, square battery cells often experience air pockets during a fill or pour. Programmable dispense speeds allow for mid-shot adjustments in material flow rate, allowing air to escape from the fill. Speed can be adjusted back to full speed once the material is past the point

of concern, allowing necessary production speeds to be achieved.

In battery cell power distribution applications, the challenge is to consistently apply the exact bead size. For long sealant or adhesive bead requirements the length may exceed the volume of the meter and require material reload, resulting in a gap or overlap in the bead. By using continuous-flow meters such as Nordson's servo-driven metering systems, reloads are not necessary before the end of the bead, to help ensure the perfect application.

Whatever the sealant and adhesive material dispensing requirement, battery assembly solutions must deliver consistent precision, accuracy and machine life, with equipment such as from Nordson that dispenses exactly the right amount every time; even with highly abrasive materials.



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Tested and proven power electronics modules

►► Lenze Schmidhauser is a leading manufacturer of drive solutions for mobile use. The company is focusing on the Mobile system of modular products specially de-signed for commercial vehicles. This system comprises double inverters, DC/DC converters, and various combination modules.

Manufacturers can put these products together from a catalogue to quickly and easily create a custom-made system for the drive control of auxiliary units and the provision of energy for the on-board power supply in their individual applications. This means the user can cover a large range of applications efficiently and economically with only one family of products and react flexibly to new demands. The Mo-bile set of modules is tested and proven in series production, and it is continually being refined and extended – for example, with the new DCU single inverter S for the control of air-conditioning systems and compressors. Lenze Schmidhauser offers its customers the best combination of expertise and series-product competence for the electrification of specific vehicle tasks.



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Heat transfer technology

►► Slovenian company, Talum, has leveraged its experience as primarily an aluminum producer to create a new brand innovation for electric vehicles. It has created a heat transfer plate exchanger product called Heatraplates, which is targeted specifically for recognized use in the automotive and marine industries for cooling of battery packs.

Heatraplates are in demand in situations where very high efficiency is required, and at a moderate price, for the heat transfer of plate exchangers. These include high-efficiency

coolers in household and commercial refrigerators, solar receivers (solar thermal collectors, hybrid photovoltaic (PVT) panels), manufacturers of sanitary heat pumps and manufacturers of battery packs for electric vehicles.

With its innovative approach and state of the art production of roll-bond aluminum flat plate heat exchangers, Heatraplates represents the future of heat exchangers for cooling and heating of battery packs or larger cells, as well as other electrical components where thermal management is required.

Talum's production of roll-bond Heatraplates is based on tradition of 40 years of production and roll-bonding process evolution. Further growth of roll-bond technology is driven by enthusiastic young engineers striving to push new boundaries in environmentally friendly energy efficient heat exchangers, as they face a future forecasted to have high demands for cooling plates as a result of e-mobility growth.

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Pioneers in waste

►► Transfluid North Europe has been the key supplier of the Geesink Norba electric and hybrid refuse waste trucks since 2012.

In collaboration, it designed from scratch the first li-ion powered waste truck called V6 to reduce the weight and to improve the payload. The proof of this successful partnership has led to more than 200 trucks already supplied.

Transfluid is supplying all components, from the electric motor to the charge connecting cords, as one complete power and drive package, and just-in-time to

the production facility located in Emmeloord in the Netherlands.

Geesink Norba believes that by 2020 any fleet should be able to collect and manage more resources totally emission free. As pioneers in waste they have been engineering and developing electrical and hybrid waste management solutions since 2003. Transfluid North Europe is assisting them with the results and progress they have made.

FREE READER INQUIRY SERVICE

To learn more about Transfluid, visit:
www.magupdate.co.uk/PEHV



Silicone solutions for componentry

►► Electronic components need protection from moisture, dust and contaminants found in everyday use. This protection can be provided by using RTV (room temperature vulcanizing) silicone elastomers for bonding, potting, encapsulating and coating of sensitive electronic components. The CHT SilSo electronics range has outstanding high temperature and weather resistance, in addition to cushioning vibrations, offering

excellent electrical insulation and heat dissipating properties.

CHT offers innovative silicone solutions, tailored to meet the individual requirements found in a range of different electronic applications. Where high power electronic components generate unwanted heat, CHT Silcotherm silicones can be used to dissipate that heat away to a suitable heat sink. This enables the design engineer to choose one product,

such as an adhesive for bonding or an encapsulant for protection, but with the additional functionality and benefit of thermal transfer. The result is longer life and improved performance of the component.

Investment in high specification laboratories in Europe and the USA, ensure that the CHT technicians can focus on developing and delivering application-based solutions.

These electronic applications are found within the aerospace, LED, aviation, telecommunications and automotive industries. However, there is a particular special interest in the use of silicones to support the development of electric vehicles and renewable energies.

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Our configuration team has the capability to design, manufacture, test and integrate high voltage cable assemblies according to your individual specifications and requirements. We can provide single prototype products through to small series production. With manufacturing based at our facility in Lichfield, product turnaround can be offered in 1 - 2 weeks, depending on available stock. We also offer "build to print" services, depending on customer requirements. Based on approved Tyco Electronics tooling and processes, Continental Engineering Services can deliver cable harnesses with shielded or non-shielded wires and provides test capability including crimp integrity and HV isolation.

Product	HVP800 	HVA280 	HVA630 
Keyway	Multiple key options available	Multiple key options available	Multiple key options available
No. of wires	2 or 3 positions (no. of terminals)	2 or 3 positions (no. of terminals)	2 or 5 positions (no. of terminals)
Connectors	90° and 180°	180°	180°
CSA	35mm ² and 50mm ²	2 - 5mm ²	4 - 6mm ²
Wire Range	For use with discrete shielded wire	For use with multicore or individually shielded wire	For use with multicore wire
HVIL	Integrated internal	Integrated internal	Integrated internal
Voltage Rating	1000V	up to 600V individually shielded and up to 850V multicore wire	850V
Current rating	Up to 250A	Up to 40A	Up to 40A
Temp. range	-40 to 140 °C	-40 to 140 °C	-40 to 140 °C

Please address your requests to: harness-sales@conti-engineering.com

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Smart material testing

►► Representatives of the electric vehicle and automotive supply chain have requested to the members of the IPC D-70 E-Textiles Committee for testing and reliability standards for e-textiles products subjected to 300V to 450V.

To address this, the E-Textiles Committee, a group of nearly 200 innovators, manufacturers, designers, material suppliers, testing laboratories, and academicians who develop open, international standards for the e-textiles ecosystem, is breaking ground on a specification and test methods for e-textiles products (with components) used in high-voltage applications.

Because the focus of this standard will be the automotive industry, in addition to voltage

requirements, this specification will include simulations of other conditions encountered during automobile operations such as high heat and high vibration. The group has compiled a list of automotive OEM test methods and important key performance characteristics and seeks the automotive industry's input to validate the characteristics, add others, identify test methods and share performance expectations through an open industry survey. Using the feedback from this survey, the group will outline a draft industry standard and to identify gaps in industry test methods.

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DID YOU KNOW?

Hyundai and Uber reveal electric flying taxi

Electric aviation is taking off with a fully-electric air vehicle taxi concept that can carry up to four passengers autonomously at speeds of 290km/h (180mph) for 100km (60 miles). The two companies jointly developed the PAV (Personal Air Vehicle) model, S-A1, for Uber's elevate initiative, which sees it employ electric vertical take-off and landing (eVTOL) for aerial ridesharing purposes.



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Impregnation machines for e-motor production

►► Since 2008, bdtronic has developed a special impregnation technology, which is needed to produce highly efficient e-motors. The mechanical engineering company based in Weikersheim, Germany, offers different machine concepts for impregnation of hybrid and full electric motors, especially with trickling process.

Bdtronic has delivered and installed several high-volume machines at German Tier 1 automotive suppliers and several low-volume impregnation machines to German OEMs.

The company recently announced that it will supply systems for electric motor production for the Audi Premium Platform Electric (PPE) and deliver the first high-volume production machine for impregnating e-motors. This high production machine has a short cycle time and a very high production volume.

With more than 4,000 installed machines worldwide, bdtronic is one of the world's leading machine manufacturers for dispensing, impregnation, hot riveting and plasma technology. Bdtronic provides entire system solutions for assembly and production automation to manufacturers in the automotive, electric and electronics industry, medical technology and renewable energy.



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Is solar the answer?

The evolution of materials for efficient and flexible solar technology will take the burden off the grid



Dr Franky So, chief technology officer of Nextgen Nano, debates the ecological and economical energy benefits of photovoltaic solar panels, and why a new breakthrough is looking bright for EV applications

Research has revealed that electricity produced from solar cells reduces air pollutants and greenhouse gases by about 90%, compared with conventional fossil fuel technologies.

However, despite seeming like the perfect renewable energy solution, arguments persist against photovoltaic panels (PVs). These include that it's more expensive to produce power from solar energy than traditional fossil fuels, such as coal and natural gas. Another argument is that solar thermal energy systems are more expensive per unit of energy generated; although a counter argument would be that solar energy is cheaper over time because it lacks feedstocks.

There are several different types of photovoltaics. About 90% worldwide are based on some variation of silicon, which takes many forms depending on the element's purity. This purity depends on how perfectly aligned the silicon molecules are and determines how well the cell is at converting solar energy, known as the photoelectric effect.

Solar cells made of monocrystalline silicon (mono-Si) contain cylindrical silicon ingots. They have the highest efficiency rates, typically 15 to 20%, because they are made of the highest-grade silicon. Yet, they are also the most expensive and the circuit will break down if it is even partly covered by dirt or shade.

Polysilicon (p-Si), or polycrystalline silicon, cells are cheaper to produce than their mono-Si relatives, with a slightly lower heat tolerance. However, their disadvantages include an efficiency of just 13 to 16%, as well as lower space efficiency.

Generally, the solar industry highlights the low costs of p-Si and also the technical components of solar cells, yet these components represent less than half the cost of an

installed solar system. Larger costs arise from installation, maintenance, insurance and operation.

Thin solar panels, many of which are in the early research and testing stages, have showed the most potential for efficiency. This especially applies to Copper Indium Gallium Selenide (CIS/CIGS) solar cells. However, newer thin film technologies degrade quicker than older models, offsetting much of the presumed benefit.

Some argue that the only way to economize power consumption is not with the use of PVs, but simply by using less power overall. But, an evolution in PV technology that uses lightweight organic polymers in place of silicon could hold the answer to issues of efficiency, economy, and burden on electrical grids.

By combining organic semiconductors and PVs, the result is cells that have the potential to be more efficient, and can be used to make flexible and semi-transparent solar panels. Given the high efficiency of polymer solar cells, it's expected that the efficiency of transparent solar cells can reach beyond 13%.

What makes the system different is the use of nanotechnology. In the case of PVs, it's likely that nanotechnology will make solar power more economical by reducing the cost of constructing solar panels and related equipment.

Possible applications of this technology have the potential to transform and decentralize energy usage for EVs. Rather than simply plugging EVs into charging points connected to the grid, there's potential to charge the vehicle through panels contained within the car itself. This could alleviate the burden on electrical grids where at least 89% of air emissions associated with electricity generation could be prevented if electricity from PVs displaces electricity from the grid. 

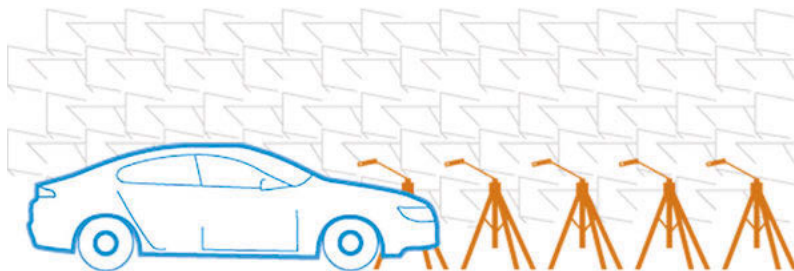
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