

Ricardo Quarterly Review

Q4 2019



# RQ

A focus on the latest in technology,  
innovation and sustainability

# QUITTING CARBON

With the climate crisis now in sharp public focus,  
Ricardo's environmental experts chart the course  
to net-zero carbon - by 2050 or earlier





Creating a world  
fit for the future



# Virtual Engineering

Virtualisation of Future Vehicle Engineering

25 – 26 March 2020 • Shoreham Technical Centre

A 2-day interactive conference



**Ricardo's inaugural Virtual Engineering event will take place at our global HQ in Shoreham-by-Sea from 25 – 26 March 2020. Book your ticket today.**

This 2-day conference will explore current trends and future potential developments in the virtualisation of engineering as we believe that increased virtual toolchains are essential for future vehicle development.

- **Reduce development time and cost**
- **Design right first time**
- **Improve testing efficiency**

**Secure your place today:**

**[www.ricardo.com/VE](http://www.ricardo.com/VE)**



# CONTENTS

Ricardo Quarterly Review · Q4 2019

10



08

## NEWS

### Industry news..... 04

Climate crisis intensifies; trucks explore greener power; clean vans, clean hydrogen cars; VW's massive EV move; Formula 1 chases net zero

### RQ viewpoint ..... 07

#### Electric trains must come clean

Jon Brown of Ricardo Rail on what zero emissions means for each form of transport

### Ricardo news ..... 24

Innovative EV rapid-charging trial; biodiversity and sustainable development; testing train traction; JCB tractor's speed record; net-zero target for UK water sector

## Q & A

### Ian Callum ..... 08

Jaguar's design director sets up his own studio: **Ian Adcock** asks him about the new-found freedoms of independence and electric architectures

## FEATURES

### Electrifying powertrains ..... 10

With the rush to electric power now in full swing, Ricardo engineers are achieving significant efficiency gains through an integrated approach to electric powertrain design. **Jesse Crosse** reports on developments that will extend EV range

### New model army ..... 15

A new Ricardo defence vehicle concept based on the Ford Ranger platform demonstrates an innovative approach to fulfilling military general service vehicle needs, as **Anthony Smith** reports

### Quitting the carbon habit ..... 18

Strikes, protests and demonstrations have brought the climate crisis into sharp public focus, prompting governments to announce net-zero carbon targets for 2050 or earlier. But how realistic are these aims? **Tony Lewin** goes to Ricardo's environmental experts for the answers



#### Head office:

Ricardo plc, Shoreham-by-Sea  
West Sussex BN43 5FG  
United Kingdom  
Tel: +44 (0)1273 455611

#### Ricardo contacts and locations:

[www.ricardo.com/contacts](http://www.ricardo.com/contacts)

#### RQ subscriptions:

[www.ricardo.com/rq](http://www.ricardo.com/rq)

#### Sales enquiries:

[business.development@ricardo.com](mailto:business.development@ricardo.com)

#### Conceived and produced for Ricardo by:

TwoTone Media Ltd

Editor: Tony Lewin

Contributors: Anthony Smith, Jesse Crosse

#### TwoTone Media Ltd contacts:

Anthony Smith: [AVSmith@MediaTechnical.com](mailto:AVSmith@MediaTechnical.com)

Tony Lewin: [Tony@TonyLewin.com](mailto:Tony@TonyLewin.com)



The task of RQ is to highlight the latest thinking in global engineering and technology in the transportation and clean energy sectors and related industries.

We aim to achieve this by presenting an up-to-date mix of news, profiles and interviews with top business leaders, as well as in-depth features on programmes – both from within Ricardo and other leading companies.

Client confidentiality is of the utmost importance to Ricardo, which means that we can only report on a small fraction of the work carried out by the company. So we are especially grateful to those Ricardo customers who have kindly agreed to co-operate with RQ and allow their programmes to be highlighted in print: without such help from customers it would not be possible to present such a fascinating insight into the development of new products, technologies and innovations.



RQ magazine is printed on paper certified as being in compliance with the environmental and social standards of the Forest Stewardship Council®.

# RQ INDUSTRY NEWS

The latest in technology, innovation and sustainability across world industries

## All eyes on Europe as climate crisis builds



Life itself is under threat if the world's biggest carbon emitters do not cut their outputs, warned the UN Secretary General António Guterres as he addressed world leaders at the start of the recent UN conference on climate change in Madrid.

This desperate warning came in the wake of record temperatures and a succession of reports lamenting most

nations' disappointingly slow progress towards reducing their greenhouse gas (GHG) emissions in line with the targets set in the 2015 Paris Agreement, as well as the relentless increase in global CO<sub>2</sub> emissions and atmospheric concentrations of the gas.

At this rate, says the UN, the world is on track for 3.2° Celsius heating by the end of the century.

**Europe is set to take the lead in aiming for net-zero emissions across a whole continent**

At the same time as the UN attendees were striving to come up with a framework for a global carbon market and tougher national targets for GHG reductions, European Union officials in Brussels were putting the finishing touches to the continent's climate plan for 2050. Describing Europe's environment as "being at a tipping point", European Environment Agency executive director Hans Bruyninckx said that runaway global heating was not the only dangerous feedback loop facing the continent, warning against natural resource depletion and biodiversity collapse in an interconnected system. An article in the journal *Nature* in November, analysing nine climate tipping points such as ice-sheet melting, concluded the planet was in an emergency.

The incoming president of the European Commission, Ursula von der Leyen, has said that climate policy is the most pressing issue facing her new administration. She has placed her faith in a European Green Deal as a sustainable growth strategy, signalling that it would require massive new investment – especially if member states that are reliant on coal are to be kept on board. The plan is expected initially to major on housing renovation and the reduction of household energy consumption.

At the same time the European Central Bank, under its new president Christine Lagarde, has come under pressure to steer the organization away from climate-damaging activities, while the European Investment Bank will be working with the Commission to bring €100 billion to the programme.

### Net-zero Formula 1: the race is on

The commercial rights holders of Formula 1 and the motorsports governing body, the FIA, have announced plans to make the sport fully carbon-neutral by 2030. A 2025 deadline to make all events sustainable by eliminating single-use plastics and offering fans greener ways of reaching the racetracks. The current 1.6 litre turbo hybrid F1 engines are the most efficient in the world, delivering more power and using less fuel, says Chase Carey, chairman and CEO of Formula 1. But little has yet been revealed about precisely how the sport's administrators and designers will achieve zero-carbon status, though the motorsport community is famous for its ingenuity and creativity when it comes to pushing the boundaries of engineering.



Source: Mercedes-AMG F1





## Trucks explore greener power

Europe's commercial vehicle operators find themselves in an unusual position: pressurizing the regulatory authorities in Brussels to tighten the rules around the emissions of trucks and buses.

The continent's heavy reliance on road freight means that some 5 percent of total GHG emissions come from trucks; yet major operators such as Nestlé are committed to a company-wide zero-carbon target by 2050, which would be impossible with current truck powertrains. Some 30 large firms are pressing the new European Commission to impose ambitious binding sales targets for zero-emission trucks and vans, figuring that a clear regulatory framework will encourage truckmakers to develop clean models and the necessary refuelling and recharging networks.

Where there is less consensus is in the technical means of achieving zero-CO<sub>2</sub> road freight. For long-haul operation, hydrogen fuel cells are favoured by Hyundai, which has shown several advanced concept trucks [pictured] and

is running a commercial pilot programme in Switzerland; it has also recently announced a tie-up with Cummins centred around a hydrogen-electric powertrain for the North American market. Toyota already has short-haul fuel cell tractor rigs operating in a Los Angeles container terminal.

Daimler, as the world's largest manufacturer of heavy trucks, has committed to completely CO<sub>2</sub> neutral operation (on a tank-to-wheel basis) in Europe, Japan and North America by 2039 and will have battery-electric trucks in all regions by 2022; its electric buses are already in series production. Daimler has a foot in the hydrogen camp, too; its Fuso sub-brand displayed a medium truck concept at this year's Tokyo show, fitted with a fuel cell instead of some of its batteries.

The outlier would appear to be Tesla, whose battery-only Semi tractor unit, with a claimed range of 600 miles, is not due until beyond 2020, despite a reported order bank of 1000 or more.

### Cleaner vans hit the market

Just as independent real-life emissions tests have shown top-selling Euro 6 light commercial vans to have huge variations compared with the legal limits, LCV makers have been scrambling to offer hybrid, battery and even fuel cell alternatives to traditional diesel power. Ford's Transit and Tourneo are now available as plug-in hybrids, and PSA is offering two sizes of battery in its mid-sized vans across all four of its brands. Renault, already a leader in battery-electric vans, is adding a hydrogen range-extender fuel cell option to the compact Kangoo and large Master, tripling the latter's range to 350 km.

## Hydrogen inches closer

A so-called 'special exhibit' from Toyota at this autumn's Tokyo motor show provides the strongest evidence yet that fuel cell cars could be moving towards a more mainstream market.

In place of the quirkily-styled original hydrogen-powered Mirai, dating back to 2014, the prototype second-generation Mirai presents itself as a stylish sports sedan that would not look out of place in a director's car bay. Exactly the same happened between the first and second

generations of the Prius hybrid. In addition, the new Mirai is built on a standard Toyota platform, and though no technical details have been released, claimed range is up by 30 percent. Further support for the hydrogen cause comes in the shape of Bosch's opening of a fuel cell development centre in China and continuing rumours that Volkswagen is to produce a platform variant configured around hydrogen power.

## NEWS IN BRIEF

Highlighting the latest thinking in automotive engineering and technology worldwide

### Where the streets are paved - with plastic

Los Angeles, several other US cities, and Tallinn in Estonia are beginning to trial a novel type of road surface - made from plastic waste. The crushed bottles, containers and packaging are melted down and mixed in with the bitumen, where they act as a binding agent. The advantage is not only that less bitumen - an oil product - is used, but that the resultant road surface is more durable than traditional pavement.

### Charge - at no charge

Among the inducements being launched to encourage the take-up of electric vehicles is an Audi incentive aimed at business users in the Munich area. The company's Charge&Fly campaign gives drivers of EVs and hybrids of all brands free parking and recharging at the city's airport, along with a transfer to their desired terminal - in an Audi e-tron, of course. Volvo, for its part, is offering UK buyers of any of its range of Recharge-branded EVs and plug-in models free charging for a whole year: the company's OnCall app monitors the vehicles' energy use and owners will be reimbursed at the end of the year.

### Power of the label

Efficiency labelling is highly effective at bringing down the energy consumption of white goods such as fridges and washing machines, and in Europe top-rated appliances now account for 68 percent of sales, compared with just 2 percent ten years ago. The problem, says the International Energy Agency, is that labelling systems are mainly confined to Europe and need to be expanded worldwide: the potential improvement in a nation's energy intensity - the amount of energy used per unit of GDP - is put at 3 percent per year.

### Porsche flies high

Porsche may join other luxury sports car makers in reaching for the skies - if a new collaboration with Boeing takes off. Several other flying cars have been exhibited at motor shows, most of them from aerospace start-ups and aimed at opening up a new sector for urban mobility. Porsche's joint venture with Boeing, Aurora Flight Sciences, seeks to explore a different angle - that of an exclusive premium personal service. No technical details have been given for the machine, though it is expected to be an electrically powered vertical take-off design. If a premium airborne sports car sector does one day emerge, the Porsche Boeing will face competition from Aston Martin with its Volante Vision, co-developed with Cranfield University and Rolls-Royce plc.

### BMW to decarbonize logistics

As part of its commitment to reducing CO<sub>2</sub> emissions along the full length of its value chain, BMW is joining the Getting to Zero Coalition - a partnership which aims to get zero-emission cargo ships into service from 2030. BMW, the first automaker to join the partnership, relies heavily on sea freight for its operations and estimates that some 50 percent of its total transportation greenhouse gas emissions come from the sea phases of the logistics chain.

## VW's biggest-ever bet

When Volkswagen announces a big investment, others sit up and take notice. But the decisions taken in the market leader's recent Planning Round 68 promise to materially change the auto industry and competitors are sure to be re-examining their own plans as a result.

Some €60 million will be poured into electric vehicles between next year and 2024, representing two-fifths of total company investment. The cash will fund the conversion and retooling of nine plants globally and enable the Group to build a planned 26 million EVs and 6 million hybrids by 2029. Some 20 million of these will be built on the dedicated MEB platform, already in production for the new ID.3 model, while the remaining 6 million will be premium models on the PPE architecture, first seen underpinning Porsche's Taycan.

The scale of the investment is unprecedented, and represents a big bet on gaining first-mover advantage for the Group's many brands by swamping the market with battery-powered models and derivatives. Seventy-five new fully electric models are promised by 2029, along with 60 hybrids. The lead plant will be Zwickau in Germany, which once produced the Trabant: this is already building



Zwickau is set to become the industry's lead plant for electric vehicles, building 330,000 units a year by 2021

the ID.3 and by 2021 will be turning out 330,000 cars annually, comprised of six models across three Group brands.

The Group's ambitious financial targets under its Together 2020+ plan suggest that it is hoping to gain major scale economies through the sheer magnitude of its EV programme – per-unit cost savings that will help ensure that the company's proposed sub-€20,000 entry-level electric vehicle can be sold at sufficient profit.

## Electric rollout



Volvo, which promises to launch a fresh electric car every year until 2025, has begun with the XC40 Recharge, boasting a claimed range of 400 km. The model has been substantially re-engineered for top-level safety, the battery residing in its own extruded aluminium safety cage and crumple zone; the frontal structure is also redesigned to compensate for the lack of an

engine. BMW's i4 (prototype pictured) is due in 2021 and will be one of 25 electrified models across the Group. Its all new fifth-generation powertrain is capable of "V8 levels" of performance, with up to 530 hp; the high (but unspecified) voltage 80 kWh battery weighs 550 kg and offers ranges of up to 600 km. Versions of the powertrain will first be seen in 2020's iX3 SUV and in the flagship iNext, also due in 2021.

Volvo XC40 Recharge (inset) and 2021 BMW i4: contrasting approaches to EV design



## SUVs sabotage Europe's CO<sub>2</sub> progress

Manufacturers selling passenger cars in Europe are looking ahead to 2021 with some trepidation: corporate CO<sub>2</sub> emissions will have to be cut by an average of 19 percent in order to avoid hefty fines. Given the industry-wide plans to launch hybrids and electric vehicles, those targets could perhaps be attainable. Unfortunately for many, however, the current boom in sales of SUVs is getting in the way.

For while high-riding crossovers, 4x4s and SUVs may be great at keeping the cashflow rolling, they are heavier and thirstier than regular models and, with 40 percent of all sales now classed as SUVs, they make it harder for each automaker to reduce its CO<sub>2</sub> average. The International Energy Association estimates that the 200 million SUVs

worldwide are among the largest contributors to the rise in global emissions since 2010, though automakers prefer to blame the switch away from diesel in the wake of the dieselgate scandal.

European NGO Transport & Environment, for its part, says that every 1 percent shift to SUVs has 7.5 times the CO<sub>2</sub> impact of a similar shift away from diesel. The interim answer seen by some commentators is a move to electric SUVs: under the European weight-based CO<sub>2</sub> target calculation formula, these would offer automakers the twin benefits of much lower emissions as well as an easier target, thanks to the battery models' greater mass.



## Shipping needs to shape up

Pressure is growing on international shipping operators to reduce the CO<sub>2</sub> and pollutive emissions of their vessels by getting them to steam more slowly. Shipping accounts for 3 percent of global greenhouse gas emissions and its authorities last year agreed to cut the sector's CO<sub>2</sub> by 50 percent by 2050. Ships transport four-fifths of the world's goods, and a container shipping company has just joined Ryanair in the EU's coal-dominated top ten of worst emitters.

Reducing speeds by 20 percent would reduce shipping GHG emissions by between 24 and 34 percent, according to CE Delft. The proposal is being presented as a win-win by NGOs and campaign groups. Slower speeds not only reduce the amount of fuel consumed by ships but also help cut the very high levels of noxious sulphur and nitrogen oxides emitted. In addition, says the report, compiled by Seas at Risk and Transport & Environment, the speed reduction would cut noise by two-thirds and reduce the chance of whale collisions by three-quarters.

## Safer e-scooter

The worldwide craze for e-scooters is posing problems for urban planners and safety authorities, with many cities unsure whether these machines should travel on the road or the sidewalk. Daimler's truck engineers have anticipated this issue and the latest versions of its Mercedes Actros trucks now feature Sideguard Assist, a system which monitors the nearside of the truck to warn the driver of any hard-to-see pedestrians, cyclists and e-scooterists who could be in their blindspot when turning into a junction.



# VIEWPOINT

## Electric trains must come clean too

**Jon Brown** – UK business development manager, Ricardo Rail



An interesting article from the Financial Times did the rounds online a few weeks ago [*London Underground: The Dirtiest Place in the City*, 5 November 2019] suggesting that the worst place in London for air quality is down in the depths of the deep tube lines, where particulate emissions from brakes, electrical contactors, motors and humans [skin, hair etc] result in some very poor air quality readings.

To some, particularly those who have lived in cities with subterranean metro systems, this may not be a great surprise. However, it does lead to a question that crops up regularly in my mind and in the working world around me. What exactly are 'zero emissions' – as trumpeted by electric and hybrid vehicles, amongst others? Certainly, they are not zero in any real sense of the word, nor even zero at point of use. Clearly, there isn't a tailpipe on an electric train or car, but there are braking systems, tyres and the wheel/rail interface, each of which will be a source of particle emissions, and significant amounts in some cases.

London Underground has worked tirelessly for many years on reducing the particulate count in the tunnels of the city's tube network. However, with a ventilation system that was designed to utilize the motion of the trains to circulate the air within the network, the entrainment of particle matter in the resulting high-speed airflows is inevitable. The current approach of cleaning and then sealing the residual deposits on tunnel surfaces is novel, but it's the type of initiative that is essential if the quality of the air available to the tube's passengers is to be improved.

On the surface rail network, Ricardo's rail and air quality teams are researching the issue of pollution hotspots such as terminal stations and interchanges served by non-electrified fleets; our specialists are examining potential abatement options for the immediate, medium and longer term. This work includes both the management and operation of the existing assets, such as filtration systems, and minimizing engine running while stationary.

Longer term, Ricardo is also

researching more advanced options including the use of patchwork electrification and last-mile battery operation, to avoid the use of diesel engines in sensitive locations. In the Netherlands, where electrification is extensive and diesel usage is comparatively low, discussions are currently focusing on non-exhaust sources of PM2.5 emissions, such as those arising from the wheel/rail interface, the action of pantographs on the overhead contact lines, and from friction-based brakes.

**"I believe that we need to realign our expectations, our conversations and our messages on what does and what does not constitute zero emissions for each form of transport"**

In summary, therefore, I believe that we need to realign our expectations, our conversations and our messages on what does and what does not constitute zero emissions for each form of transport. We are dealing with highly complex sets of systems interacting with each other and understanding the full environmental impact across the life cycle of any proposed solution is very difficult, even for those who spend their lives studying it. We need to move beyond a simple linear set of good/bad arguments and do our bit to educate those tasked with making decisions, along with the population at large, in a clear, fair and impartial manner about the complex nature of these issues and the practical solutions that can be offered. By addressing the issues at hand in each individual case and examining how we can most effectively use available technology to minimize the impacts to the population at large, we can thus improve the quality of air available to those who work on or live close to the railway as well as those that travel on it, both on the surface lines and underground.





# Design beyond Jaguar

Leaving Jaguar after two decades as design director, Ian Callum is closely identified with today's modern and progressive range of sedans, sports cars and SUVs – models which represent a dramatic break away from the brand's earlier classical style. Now installed in his own independent studio, Callum tells **Ian Adcock** about the new opportunities presented by the revolution in automotive drivetrains

**You could have a relaxing retirement after a successful career and rest on your laurels – so why go through the angst of establishing your own design consultancy?**

I had been discussing the idea for the past decade but decided to leave Jaguar when I reached 65. There's never a good time to resign when you're leading [a] design [studio] because there's always an ongoing cycle, but by that time we had launched the I-PACE and finished the next-generation XJ. After 20 years at Jaguar it felt like the right time. Although I spent two days a week working alongside the designers, sketching, commenting and editing, when you are responsible for 400 people you become more of a manager and less of a designer. I wanted to prove to myself that I still had it in me to design products, not just cars. I am passionate about good design and believe that people will pay premium prices when it's combined with quality materials and craftsmanship – whether that's watches, luggage, furniture, cars or aircraft interiors.

**Nevertheless, your first public project as Callum Design is a limited-edition revamped Aston Martin Vanquish.**

Yes it is, and I make no excuses about that. It's very close to my heart; originally it was created by me, Jac Nasser and Bob Dover – it's a very spontaneous design, and you can see that in its lines. But it was never given a second chance, an update, and I believe it deserved that and, to be frank, I have the right to do that.

**So, it's more than just a facelift – does it signpost the way Callum Design will develop?**

In a manner, yes. What we are not is a jobbing design consultancy for OEMs: I've already turned down several approaches, which is quite satisfying. The Vanquish 25, so called because that's the production number it's limited to, is completely stripped back to the bare metal, the interior is gutted and refitted with high grade materials [and there are mechanical upgrades]. Aston is happy with what we're doing.

**Does that mean you will do limited production runs?**

Yes. Within 50 miles of here, on the outskirts of Warwick, there's every conceivable skill you require to engineer a car, from building

[or developing] a Formula 1 engine to artisan trimming, veneer skills, carbon fibre lay-up. With the exception of Turin, perhaps, that's unique in the automotive sector. We have the experts on board, including former Jaguar employees and colleagues.

**Do you see the opportunities for Callum Design in, say, the electric vehicle sector or autonomous driving?**

They are separate challenges: autonomous driving is on the far horizon for me, but electric vehicles [EVs], definitely. Because of the 'skateboard' nature of their structures, EVs present a tremendous opportunity to explore different design concepts that aren't available with conventional monocoque structures – in fact, I quickly sketched out a concept this morning.

**Can you expand on that?**

Take [the Jaguar] I-PACE as an example: at 36,000Nm/degree it is the stiffest Jaguar yet engineered and with its sandwich construction it has its own built-in integrity; the body is almost incidental. There's an entity you can take and build different bodies on: you can't do that with a standard unitary design. Not all EVs will be that way because they will go through a period when some will still cater for both internal combustion engines and batteries – and the skateboard's higher centre of gravity militates against low-slung sports car concepts.

**Do you need to keep the hard points, A-post locations and so on?**

No, you can move away from that because the structure's integrity stems from the platform and the basic structure of the body becomes a separate entity. When we did the I-PACE, the A-pillar location was dictated by the front wheel: we couldn't go further forward than that, but we had more flexibility where it sat. With 'skateboard' platforms I think we can put the A-pillar where we want. Having said that, it depends on how much work you want to give yourself. Everything tends to be below the wheel line in terms of height and that leaves the middle free, so you can focus on where the occupants sit: in a sports car they would be further back with more distance in front; in a five-seater you can move them forward, which is what we did with the I-PACE.



### How might the proportions of the car change?

Because you don't have a big engine ahead [of the firewall] you can move the occupants closer to the front of the car. Admittedly, there's a slight limiting factor here as there's a certain amount of mass that has to be accommodated and crash requirements are becoming more stringent, especially the off-set barrier test in the United States, this might negate [the] short front ends that designers want. If you see a lengthy bonnet on an EV it will be filled with inverters, chargers and, maybe, a front trunk or 'frunk' with what little space is left, but a lot will be down to crash and other legal requirements.

### So will it be a challenge to move away from traditional two- and three-box designs?

Yes. I think [the] I-PACE is as markedly different as you will get, because you still need a front end for protection and packaging. I think if you get into the one-box scenario you tend to just have a deeper windscreen with more dashboard, which is what the Renault Espace and the like were all about. I [tend to] say that what makes the shape of a car is a human being: our eyes are at the top, our feet at the bottom and we sit on our bums in the middle. That makes the shape of the car and you have to put glass around it and the protection elements. The pivotal point is the front cowl and everything else flows from that to the front and to the rear. It's then down to my imagination to manipulate the interior - and there's more scope to do that with an EV than ever before.

### Does that mean the Silicon Valley disruptors will find it a challenge to come up with innovative concepts?

I think they will discover that the parameters will get them to a very similar solution to what we've been working with for the past 100 years. It's based on our anthropometrics and [on the requirements of] legislation. Once you put all those into the mix you come up with pretty well defined solutions. What I do know



is that those who have gone in to disrupt haven't always been that successful. We will wait and see - I am quite open to being pleasantly surprised. [RQ](#)

#### Ian Callum

Born in Dumfries, Scotland, Ian Callum studied Industrial Design at the Glasgow School of Art, after which he enrolled at the Royal College of Art (RCA) on the Automotive Design course. His performance at the RCA persuaded Ford to recruit him immediately and from 1978 he spent 12 years working in the company's design studios in Britain, Japan, the United States, Australia and Germany. He was then appointed design manager responsible for the Ghia Design Studio in Turin before he returned to the UK to join TWR in Oxford as chief designer in 1990 and working on projects for Holden, Aston Martin (DB7, Vanquish), Volvo, Nissan, Mazda and Range Rover. After joining Jaguar in 1999 he set in place a programme to define a new design language for the brand, resulting first in the XK and now the entire current Jaguar line-up. Callum left Jaguar in summer 2019, when he turned 65, to set up his own studio.

**Callum and colleagues in his new design studio and (below) one of their first projects, the refreshed Aston Martin Vanquish. The underside of the exhausts are inscribed "Made you look"**

**"I am passionate about good design and believe that people will pay premium prices when it's combined with quality materials and craftsmanship"**



# Electrifying the powertrain business

The rush to electric power is now in full swing, with automakers scrambling to bring battery models to market. But while much attention is being lavished on improving battery technology, Ricardo engineers are achieving significant efficiency gains through an integrated approach to electric powertrain design. **Jesse Crosse** reports on developments that will extend EV range – and even help reduce battery costs



Electric vehicles have arrived in a big way: big-name launches are a regular occurrence and almost every automaker has one or more plug-in models in its forward product programme. In short, EVs have moved into the mainstream.

For the motor industry, this means a major move away from traditional methods of design and manufacture, and the new challenge of embracing the potential that an all-electric powertrain offers. New battery electric vehicles (BEVs) provide the opportunity for a fresh approach to design and manufacture – witness the VW Group's much-promoted MEB modular EV component strategy.

Yet, despite VW's best efforts, sales of electric powertrain components by established EV manufacturers and suppliers to third parties have so far failed to take off in anywhere near the numbers needed to accelerate overall EV production. This could indicate the need for a more holistic approach to EV powertrain design, rather than the current practice of specifying a series of individual components. Accordingly, Ricardo has been thoroughly investigating many different EV powertrain configurations – and the work has led to the design of an innovative 'three-in-one', multi-speed

Electric Drive Unit (EDU) concept.

"Efficiency is clearly important," explains Rob Parkinson, Ricardo's global technical expert for transmission and driveline systems. "However, cost is paramount if EVs are to be adopted in larger numbers, and it's fair to say that nobody in the industry is absolutely clear as to which kinds of technology collections are going to be most cost effective overall. That's fundamental to the work we're doing now with EDUs."

Key to developing these new EDU concepts is a Ricardo-developed toolchain consisting of a variety of Ricardo and third-party software packages, all linked together to create a Design of Experiments optimization process capturing electrical, mechanical and thermal energy flows. Interrogating the results from the toolchain gives clear recommendations as to which powertrain and combination of sub-system technologies is best suited to a given vehicle.

## System approach makes

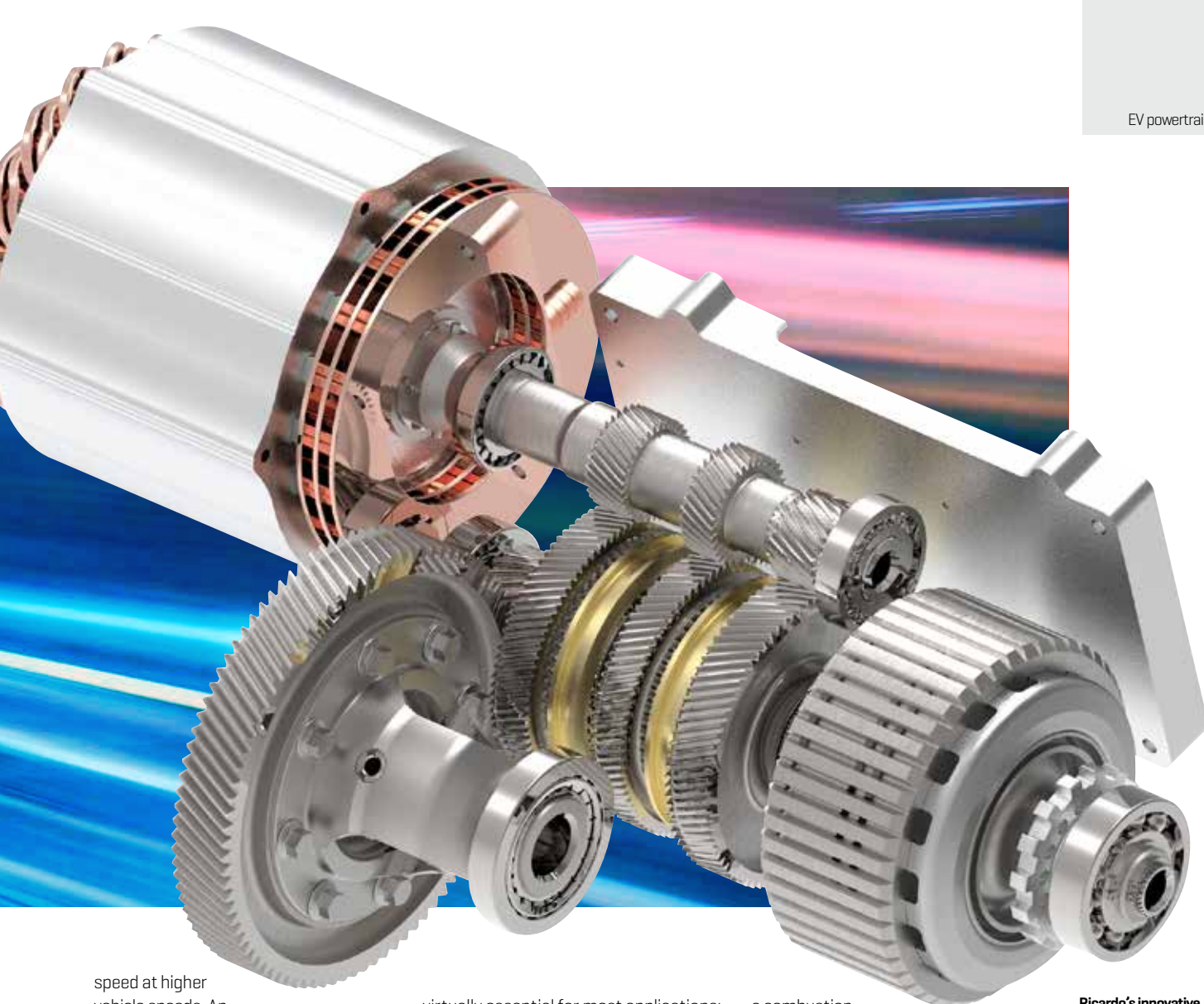
Combining an EV's electric motor with the transmission and power electronics to make a single unit is an effective way to improve efficiency and reduce cost. Scalable technology of this type could

be used by EV manufacturers across a range of EV classes – and an optimum solution that has emerged from Ricardo's work is a multi-speed EDU incorporating a three-speed dual clutch transmission, electric machine (motor), final drive and inverter.

Traditional practice has been for the transmission, electric machine and inverter to be developed separately and assembled together, simply because each component has represented a separate, expert discipline. "The downside of that approach," explains Parkinson, "is ending up with separate parts that are not necessarily perfectly attuned with one another, whereas designing an integrated system delivers the optimum combination."

Why opt for a multi-speed rather than single-speed transmission? At first glance a single ratio would seem a less complex and cheaper option. The answer lies in requirements of the electric machine used to power EVs. In a single-speed solution, the electric machine has to provide both peak torque at low speeds and peak power at higher speeds, through a single gear ratio. In the multi-speed option, explains Parkinson, "a lower ratio delivers more torque at the axle and a higher ratio reduces the electric machine





speed at higher vehicle speeds. An electric machine of a given power can be smaller in terms of torque output as well as dimensions and weight."

There are also efficiency benefits to be gained by using more than one transmission gear ratio. A traditional combustion powertrain has brake specific fuel consumption sweet spots or 'BSFC islands' in its operating range. "They are quite narrow and constrained within the working range of the engine," Parkinson continues, "but with several gear ratios you can use islands in multiple locations throughout the vehicle speed range. With an electric machine, the efficiency island extends much further over the speed range than a combustion engine, but there are still areas where it's less efficient. Using more than one ratio solves the problem, and we've seen efficiency gains of 4 to 5 percent."

Multi-speed technology does not suit every application, however, and for low-speed, lightweight city cars with small batteries, says Parkinson, "frankly, you can forget it. A multi-speed won't give you a benefit, but for a car with a wider working speed range and a bigger battery then, yes, it does." For the largest vehicles like trucks, it is

virtually essential for most applications: "Rather than attempting to make a big truck motor capable of both getting up a hill and cruising at speed on the straight and level, the solution could be to use a smaller motor with a multi-speed transmission."

### Faster is more efficient

Ricardo senior global technologist Professor Andrew Atkins sheds more light on the benefits of using high-speed motors: "Going to higher speed reduces the electrical losses by delivering power through speed rather than torque. Torque and rotor volume are linked, so by reducing the need for high torque the rotor volume can be reduced as well. Moving to higher speed solutions and multi-speed transmissions sits well with forthcoming 800-volt technology because high-speed motors need higher voltages."

A more subtle aspect of smaller, high-speed electric motors which is less marked in low-speed motors is the 'torque ripple' effect. This phenomenon is due to the fact that electric motors have preferred positions during each rotation: at speed, these manifest as non-linear torque rippling. While far less marked than the torque spikes which occur in

a combustion engine every time a combustion event occurs, it is still significant.

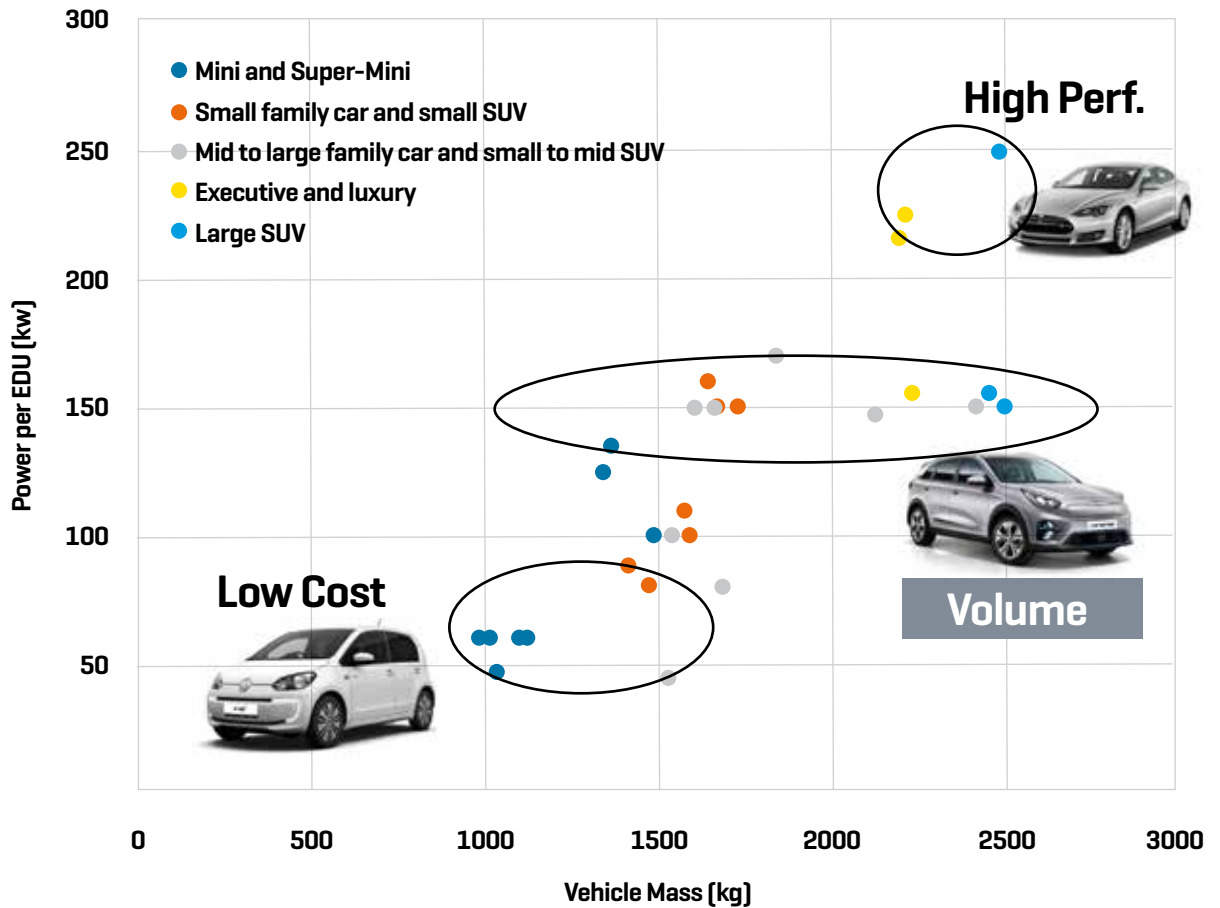
As electric machine speed increases, the amount of permanent magnet flux across the air gap creates more torque ripple and this can lead to gear rattle in the transmission, as well as other NVH (noise, vibration, harshness) issues. "With a combustion engine giving a significant torque fluctuation you can use dampers to iron that out before it gets to the transmission - but with electric machines you don't attach any kind of mitigation device and they drive the transmission directly," explains Parkinson.

However, torque ripple can be controlled electronically. "Looking at electric machines in other applications, servo motors are used in high precision manufacturing and can be minutely controlled. Automotive permanent magnet machines are fundamentally the same technology," says Atkins. "Using the power electronics, we can almost make them play a tune. With our transmissions team and motor controls team working together we can push the boundaries further forward. It may turn out that something we previously used the motor control algorithm for can be done better

**Ricardo's innovative three-in-one Electric Drive Unit (EDU) concept. This can be adapted to deliver the optimum cost-performance-efficiency trade-off for different market sectors and product types**



Ricardo predicts a wide range of electric powertrain requirements across vehicle sectors, but typically falling into three categories. Each of these can be served by an adaptation of the Ricardo EDU concept



→ with a transmission control algorithm, and vice versa. This is why the integrated approach is so important.”

### With speed comes efficiency

A further benefit of high-speed motors is that, generally speaking, they are intrinsically more efficient. Low-speed high-torque motors require higher

current, generating more heat – and this equates to wasted energy. “This is why I keep coming back to the fact that we need higher voltage to go faster. You don’t get something for nothing,” says Atkins.

### Novel transmission concept

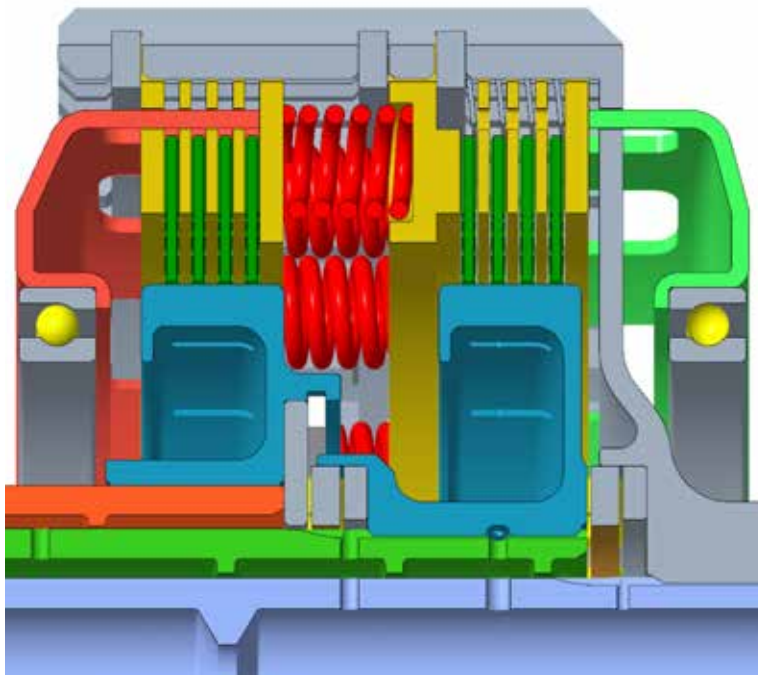
The transmission of the new EDU concept is a three-speed, wet dual clutch

unit, configured around a mid-sized, two-wheel drive SUV. “I don’t think it will ever be necessary to use more than four speeds whatever the application,” says transmission specialist Rob Parkinson. “The number of speeds chosen for a given application depends on several factors, such as efficiency, cost, packaging, inverter, motor and other vehicle attributes. In most applications the decision will be driven by the cost versus efficiency balance – for example, the fact that cost can be taken out of the battery by increasing range through driveline efficiency.”

Wet clutches protect against wear, providing longevity and raising the potential torque threshold of the transmission across a wider range of applications. The design is unusual because the default position for the clutches is one closed and one open: the usual practice in most cases is for both clutches to be open. In the EDU the closed clutch is attached to gears one and three and the open clutch to gear two, the logic being that no energy is required for closing the clutch on gears one and three, only two. There’s a good reason for this; under the WLTC cycle 70 percent of the driving time is spent in first or third gears. Synchronizers are included on all three ratios so idle gears are disengaged to avoid losses in the clutch.

### Key features of the 3-speed DCT solution

The clutch pack has been designed with a focus on minimising losses, to improve overall vehicle driveline efficiency. The dual clutch is normally closed on 1st - 3rd intermediate shaft to maximize efficiency [over 70 percent of time is spent in 1st or 3rd gear over the WLTC]. Opposed actuation limits loads on shaft bearings and leads to smaller bearings and less frictional losses. A synchroniser on 2nd gear in addition to 1st and 3rd gears further reduces losses





## Oil cooling makes sense

Even with so much optimization, a multi-speed system still incurs additional losses compared to a single speed because of its additional bearings and clutches, its gear train and its pump requirements. "The raw output from our toolchain simulations helped us arrive at the best approach to take to minimize those ancillary losses," says Parkinson.

The oil cooling of the EDU is a good example: a single cooling system draws heat from the transmission, electric machine and inverter. If the oil is routed in series rather than in parallel it is possible to reduce the flow rate and minimize energy consumption. Cold oil flows first to the inverter, then the electric machine and finally the bearings in the transmission. Starting from cold, the system picks up heat through losses in the motor and inverter which then helps heat the transmission oil, reducing friction in what is a neat, virtuous spiral.

The entire system is sealed for life, but that is not without its challenges. "There's some work still to do with transmission oil being used in three-in-one EDUs," thinks Parkinson. When using a transmission oil to cool all three elements, the fluid collects magnetic debris from the wear in the gearbox

parts and it's not clear at this stage what impact that could have on the electric machine over time. Also, the specific heat capacity of oil is much lower than that of water, so for the same energy flow more coolant flow is required. Despite that, says Parkinson, "we've made real improvements in the extraction of heat using our oil-filled cooling system. One big advantage of cooling electric machines with oil is that the fluid is not conductive and so lends itself to a closer level of cooling inside the machine than water."

The cost, packaging and weight saving of bringing all the parts together in one unit is already a huge benefit. Add to that the further benefits of a combined cooling system using just one pump rather than two or more, as well as using waste heat from one element to warm up another, and the unit becomes a fully optimized system.

On the electrical side, internal connections using bus bars instead of external cabling save cost and weight and improve safety. Reducing cost through efficient design is crucial. Economies of scale can be harder to achieve than with conventional vehicles because the cost of raw materials - such as copper and rare earth magnets - is so high.

Power electronics, however, are an area where high production numbers can really make a difference, says Atkins. "About 30 percent of an inverter cost is in power switches, and as we start to see a significant volume of these components, the overall cost of them will come down."

## New players for a sustainable future

Beyond the EDU projects, how does Atkins see electric machine technology progressing generally?

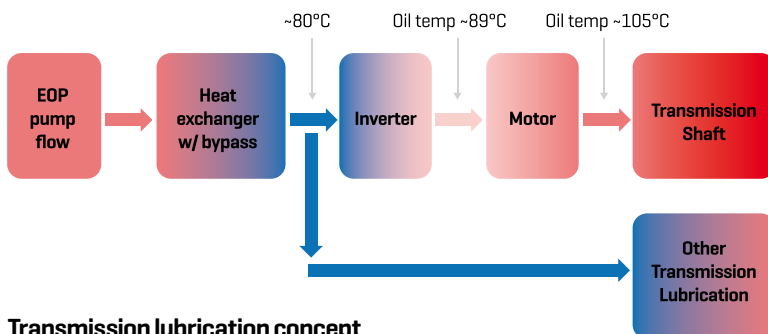
A relatively new player in the field is the axial flux electric machine. In contrast to the cylindrical profile of a radial flux machine, the axial machine is more disc like. "These machines are axially very short and there are some applications where, for packaging reasons, they are more suited than radial flux," he says. Axial flux machines are good at producing high torque at low speeds, but for high speeds the radial flux machines come to the fore.

Prompted by sustainability concerns around rare earth materials, an emerging trend is a move away from permanent magnets. Conventional machines are classed as interior permanent magnet, but there's a move towards increasing reluctance torque in production EVs. "These machines still have permanent magnets in them but they are moving more towards synchronous reluctance operation to reduce the amount of rare earth material needed," Atkins continues. "The machine can be run at faster speeds and cost and weight are reduced."

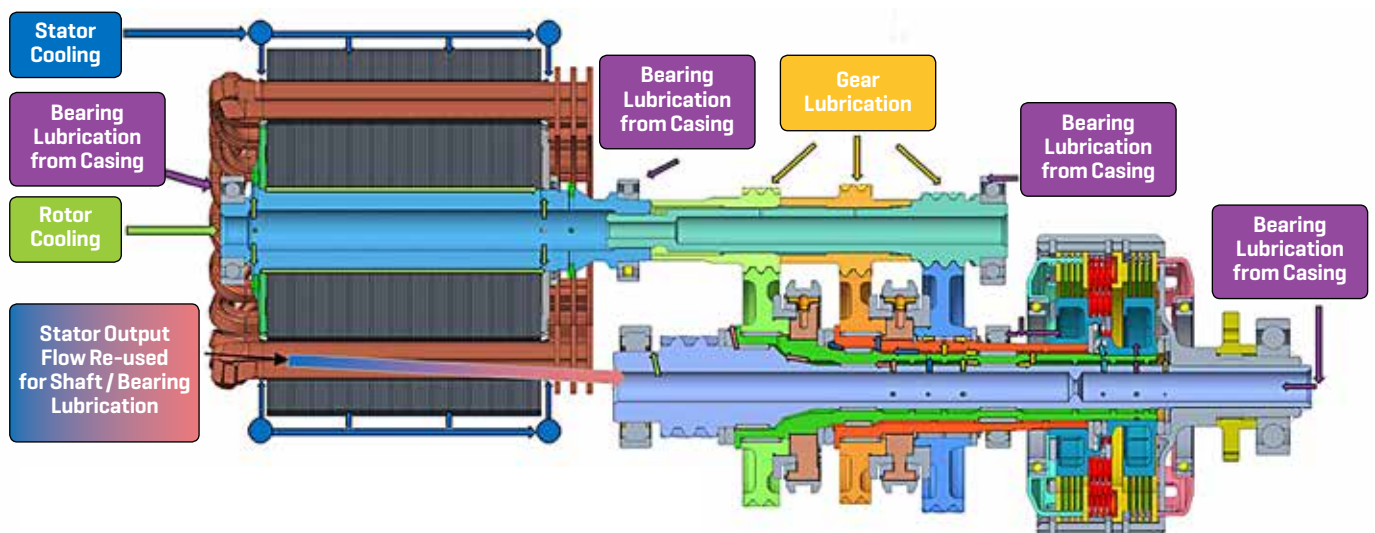
The likelihood of synchronous reluctance electric machines becoming more common is enhanced by the use of multi-speed transmissions because there is less reliance on torque. Unlike switched reluctance or full permanent magnet machines, the technology does not produce very high torque at low

**EDU cooling circuit design**  
Oil flow from the heat exchanger provides the lowest temperature oil to the inverter for improved inverter thermal stability. Inverter flow output is then supplied to the motor cooling in series to reduce electric oil pump flow requirements. Collection and re-use of motor stator output flow into transmission shaft bearing lubrication allows for further EOP flow reduction whilst also assisting with transmission warm up

## EDU cooling and lubrication flow overview

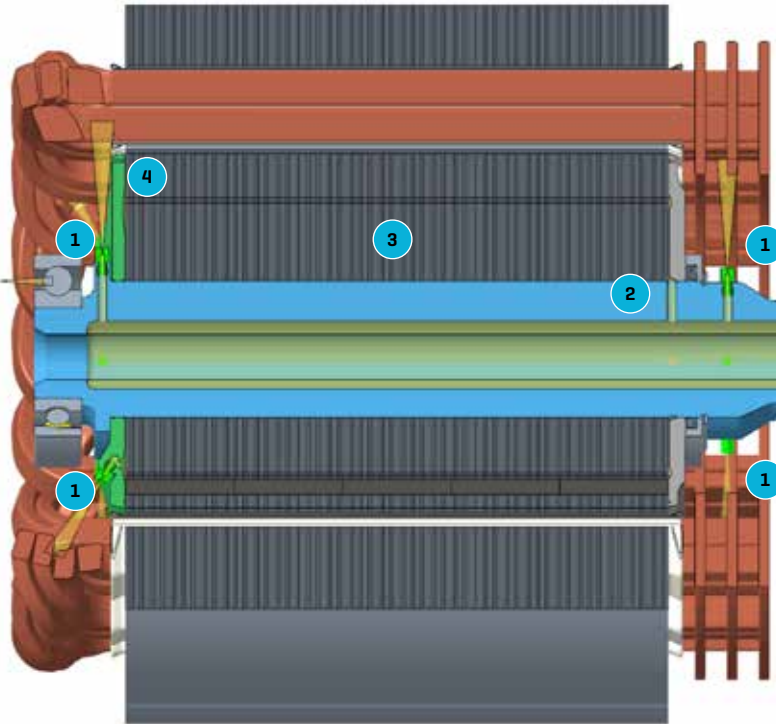


## Transmission lubrication concept



**Motor cooling**

The EDU motor is cooled using the transmission oil, using ten jets on each side to cool the end-windings [1]. No cooling of the back-iron needed thanks to active jet end-windings solution efficiency. The magnets in the rotor are also oil cooled as follows: holes feed the oil from the shaft into the void behind the end cap [2]; the inner flux barrier beside the magnets is used as an oil gallery [3]; the oil feeds out through jets in the end cap at the free end [4]



speeds. Applications like excavators, which need very high torque at minimum speed, would require switched reluctance solutions instead, but for passenger cars, synchronous reluctance motors in conjunction with multi-speed transmissions would be ideal. "This would take us further down the path of eliminating the use of rare earth metals altogether," Atkins continues. "There's a real possibility of replacing the

permanent magnet with ferrite solutions too." Work is also going on to replace copper windings with aluminium, which is cheaper, lighter and more abundant, but has a higher resistance than copper and more of it is needed in the windings.

**Formula E racing and the future**

Ricardo has three years' experience working with DS Performance in

Formula E. The DS Automobiles Techeetah racing team won both the manufacturers' and drivers' championships in the 2018-2019 season. "In a Formula E grid, 80 percent of each car is the same," explains Ricardo business development manager for Performance Products, James Sunder. "Only the electric machine, inverter and gearbox - designed by Ricardo - is different."

Using software it had developed in house, Ricardo was able to predict the overall efficiency of the driveline, minimizing oil churn, seal drag, bearing drag and so on, to develop the most efficient transmission possible. The software is so accurate that it is possible to predict differences as small as 0.5 percent - and because there is a direct correlation between overall driveline efficiency and lap time, any reduction of losses in the driveline improves the performance of the car. The very important lessons learned in this demanding field are expected to cross over into road car development.

What comes next? Ricardo is continuing its research into producing high efficiency cost-effective electric powertrains capable of underpinning not just BEVs but fuel cell electric vehicles as well. What is clear from the work so far is that treating an Electric Drive Unit as a single system rather than a collection of separate components gives significant efficiency gains - and the best thing is that there is still more to come. [RQ](#)







# NEW MODEL ARMY



Unveiled for the first time at the Defence and Security International exhibition in London in September, a new Ricardo defence vehicle concept based on the Ford Ranger platform demonstrates an innovative approach to fulfilling military general service vehicle needs. **Anthony Smith** reports

Manufactured in the Ford's South African facility and sold globally, the Ranger is a common sight on the highways of Europe. A vital workhorse in sectors ranging from construction to agriculture and forestry, the Ranger is the continent's best-selling pick-up and is also valued for its versatility, durability and high towing capacity in leisure applications.

However, while the model is familiar in many differing roles, it has not - until now at least - been seen as a candidate for military service. This new Ricardo-developed Ranger concept builds on the

wealth of experience of the company's special vehicles team and is a modern interpretation of the Ricardo approach to cost-effective military vehicle design, a heritage that stretches back almost three decades.

The special vehicles team, led by director Paul Tarry, has long championed the innovative design and manufacture of defence vehicles; wherever possible, these have used commercially available platforms and components. Back in the early 1990s Tarry and his team noted that British forces were using large fleets of the then-current Land Rover

Defender for basic transportation, but that they also had an occasional requirement for light-attack vehicles. The result was the WMIK (Weapons Mount Installation Kit) concept. This Ricardo innovation comprised a roll cage and ring-mount weapon system kit, as well as a strengthening of the chassis and body structure across the fleet of the otherwise standard transportation vehicles. When required, standard Land Rover Defenders could be WMIK equipped and deployed as required in theatre, both in front-line use and for special forces operations.

## The Ranger general service vehicle concept in overview

### Powertrain:

- Range of powertrain options, including 213 hp, 500 Nm, 2.0-litre EcoBlue bi-turbo diesel, mated to an advanced new 10-speed automatic transmission

### Protection:

- Rollover protection system
- Ring-mounted weapon system
- Armoured ballistic underfloor & glass level 1
- Heavy duty/lightweight front and rear bumpers
- Skid plates for radiator, powertrain, fuel tank
- Rock sliders
- Improved wading and fording protection
- NATO IRR paint and camouflage
- Four-point seat harness

### Electrical:

- Battery isolator switches
- 24V comms power [MIL-STD-461]
- Comms kit and antenna
- EMC radio frequency interference reduction
- Blackout, IR Lighting, NVG compatible instrument and warning lamps
- Trailer connection

### Tie downs, towing and recovery:

- Tie down and recovery shackle solutions
- Heavy duty bumper with winch
- NATO tow hook
- Heavy duty wheel rims and all-terrain tyres

### Payload, chassis:

- Ride height increase
- Up-rated springs, dampers, brakes

### Miscellaneous:

- Smart stowage solutions: trays, weapon mounts, netting
- Pioneer kit
- Boiling vessel
- Compressor
- Diesel-fired cabin heater
- Rubberized floor coating

### → Changing front-line requirements

The WMIK Land Rovers were successfully deployed in a range of theatres, including the intervention in Sierra Leone in 2000 and in the early stages of the conflicts in Afghanistan and Iraq. But, over time, the nature of the threat to mobile forces changed, and this, as Paul Tarry explains, required a new approach. "With the increasing sophistication of improvised explosive devices and the asymmetric nature of these modern conflicts, it became clear that larger armoured vehicles would be required for most front-line operations."

This changing requirement led to major refitment programmes, both to the WMIK units and to the Vixen general transport vehicle based on the same Land Rover platform. These provided significantly improved ballistic protection, and parallel upgrades to the powertrain helped accommodate increasing vehicle mass and electrical requirements. Such upgrades were, however, effectively a stop-gap solution while Ricardo worked in parallel on its Ocelot concept, which was to become the highly successful Foxhound vehicle in service with the British Army. As with most armoured vehicles, the Foxhound concept was developed by Ricardo from a clean-sheet design, albeit one that drew extensively on commercially available powertrain systems and motorsports technologies for the crew pod. Almost the entire fleet of Foxhounds were built on a specially configured production line at Ricardo.

### Challenge of fleet obsolescence

Forces operating fleets that include vehicles manufactured in previous decades are being faced with more and more significant obstacles to the effective maintenance of their operations, Tarry explains. "Many such products are based on what are now very old and in most cases obsolete platforms – models that are not necessarily well supported by an official spare parts supply chain; in certain cases for more specialist vehicles, the original manufacturer may even no longer exist."

"As these fleets have aged," he continues, "automotive technology has moved on considerably, and new vehicles now offer significant end-user benefits in areas such as fuel economy, reduced emissions, better NVH, enhanced performance and durability, and better standards of occupant safety. When considerations of ready availability of spare parts are also considered, the argument for the replacement of older vehicles still nominally within their service life can be operationally and economically compelling for military customers."

The case for a fresh platform-adapted approach is also one that holds attractions for new fleet applications too. While front-line roles may in general no longer be considered appropriate for this type of cost-effective vehicle concept, there are other roles where it remains very attractive. Take special forces applications, for example: here, agility, flexibility and adaptability of vehicles can be more important than heavy, armour-

**The new Ford Ranger general service vehicle concept demonstrates a modern interpretation of the Ricardo approach to the adaptation of a commercially available platform as the basis for defence and other security-related applications**







based crew protection, and a modern interpretation of the WMIK concept remains extremely attractive. Similarly, for covert policing-style operations there are frequent requirements for a protected platform for surveillance and monitoring that can blend in to the urban background by presenting as a standard civilian vehicle. Moreover, for general service vehicles, defence customers need to know that their fleets offer military standards of utility, serviceability and adaptability against a wide range of possible future operational scenarios.

### Ricardo's militarized Ford Ranger

The new Ford Ranger general service vehicle concept demonstrates a modern interpretation of the Ricardo approach to the adaptation of a commercially available platform as the basis for defence and other security-related applications. The concept is intended to be available with a range of powertrain options, including Ford's powerful and refined 213-horsepower 2.0-litre EcoBlue bi-turbo diesel powertrain, which produces 500 Nm of torque for excellent load-hauling capability. This is mated to an advanced new 10-speed automatic transmission for easy, economical driving.

Key features of the Ricardo Ranger concept include options for a rollover protection system; a ring-mounted weapon system similar to that used in the WMIK; an armoured ballistic underfloor and armoured glass; lightweight but heavy-duty front and rear bumpers; skid plates for the radiator, powertrain and fuel tank; rock sliders and improved wading/fording protection; NATO IRR paint/camouflage and four-point seat harnesses. In addition, the 24V electrical system is enhanced to provide the power

requirements and electromagnetic compatibility (EMC) protection expected of modern defence vehicle applications, and the chassis can be equipped with upgraded springs, dampers, brakes, heavy-duty wheels and all-terrain tyres to provide increased ride height and greater towing capacity.

In delivering this project Ricardo has worked closely with Minnesota-based Polaris Government and Defense, in particular when it comes to support in the areas of onboard power management and C4i [command, control, communications, computers and intelligence] integration.

### Successful collaboration

"The Ricardo relationship with Ford is great," explains Tarry. "They rely upon us for our strong connections with military-sector customers and our detailed knowledge of defence and security operations, and from their side they provide proactive engineering support for our adaptation work. For example, they have been extremely helpful in adapting the controls and displays for use with night vision goggles and have also treated calibration adaptation for use on NATO standard JP8 fuel as part of their in-house alternative fuels work. These types of challenge are far from insurmountable to Ricardo, but it is far less costly, as well as more effective, to have an OEM partner that is willing to collaborate on such adaptation needs."

Tarry contrasts this with the many defence conversions of commercial platforms in other parts of the world, particularly those based on Japanese-manufactured vehicles where the country's pacifist constitution or moral objections to defence-related work can act as a barrier to co-operation. "If you base an adaptation on a platform

**The Ricardo Ranger concept includes a range of practical options including a rollover protection and ring-mounted weapon system similar to that used in the WMIK (above left), while driver display and controls are adapted for use with night vision goggles (above right)**

for which you do not have the support and co-operation of the original manufacturer, you're effectively working with equipment purchased on the grey market for which service support will not be available," explains Tarry.

The flexibility of the partnership with Ford on the Ranger concept extends beyond the design of the concept to take in the manufacture by Ricardo of specialist versions. Tarry explains that lightly modified vehicles would be produced in-house by Ford, as is already the case, for example, with some specialist forestry vehicles; However, for more bespoke defence adaptations – particularly those requiring sophisticated communications, electronic countermeasures, weapons systems and other role-specific adaptations – vehicles would probably be sold to Ricardo for conversion and onward sale to the end customer. Crucially, this collaborative approach with Ford ensures that defence fleet customers have the reassurance of an established international supply chain of parts and service.

### Conclusion

Ricardo is always open to partnering with vehicle manufacturers in the creation of bespoke, special vehicles for challenging applications, emphasizes Paul Tarry. "The Ricardo Ford Ranger concept that we have developed is perhaps the best such example to date, providing the basis of a highly cost-effective and widely supported platform for a wide range of defence and security applications.

"Our collaboration with Ford, as well as that with Polaris Government and Defense on electronics and communications, takes a robust, versatile and well-proven platform, and re-engineers and re-imagines this to fulfil multiple defence roles in an effective and very cost-efficient package." 📺

Towards net-zero  
carbon



# QUITTING THE CARBON HABIT







School-strike protests, Extinction Rebellion demonstrations around the world and impassioned speeches at the UN have helped bring the climate crisis into sharp public focus, prompting many administrations to announce net-zero carbon targets for 2050 or earlier. But how realistic are these aims, and do we have the technical, financial and organizational resources to achieve them? **Tony Lewin** goes to Ricardo's environmental experts for the answers

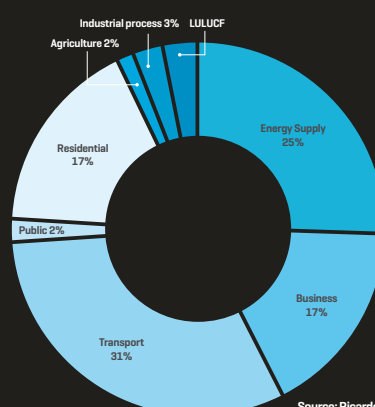
It could come to be called the Greta Thunberg effect: the sudden and widespread realization, in the closing months of this year, that immediate and far-reaching action is essential if the escalating crisis in the world's climate is to be slowed down and eventually halted.

For while millions have been risking arrest on city streets in Extinction Rebellion-style climate protests and politicians continue to make bold promises to halt carbon emissions by 2050 or earlier, it has taken a quiet 16 year-old schoolgirl's impassioned address to September's United Nations Climate Summit in New York to finally bring the message home to the mass audience.

"Entire ecosystems are collapsing," Greta Thunberg angrily told the delegates, after having first harangued them for expecting young people to solve the crisis. "We are in the beginning of a mass extinction and all you can talk about is money and fairytales of eternal economic growth. How dare you!"

On the evidence of the months that have followed, Thunberg has hit the nail right on the head. Climate change shot to the front and centre of mainstream news coverage, multinational companies rushed to sign up to the UN Global Compact to keep the global temperature rise below 1.5 degrees Celsius, and the Bank of England governor rounded on

### UK greenhouse gas (or GHG) emissions 2018



Snapshot of UK greenhouse gas emissions in 2018 shows the dominance of energy supply and transport in the CO<sub>2</sub> picture

## THE DECARBONIZATION HITLIST: ENERGY

The challenge facing this most pivotal of all sectors is aptly summed up by Dr Fatih Birol, executive director of the IEA (International Energy Agency), in his comments on the organization's latest energy report: "What comes through with crystal clarity in this year's World Energy Outlook is there is no single or simple solution to transforming global energy systems. Many technologies and fuels have a part to play across all sectors of the economy."

Even with today's policies and the ambitious decarbonization targets announced by some governments, sustainability will not be achieved on current trends, says the IEA. The momentum behind clean energy technologies is building but is currently not enough to offset the effects of an expanding global economy and growing population. In an earlier report, the IEA calculated that offshore wind power has the potential to meet the world's aggregate energy demand several times over: the Agency now

counts wind power as the third key shift in the energy market, after shale gas and solar power.

In the broader picture almost all GHG-producing fossil fuels must be eliminated to achieve zero net carbon. 'Green' hydrogen from electrolysis is widely regarded as the dream fuel, but until the electricity grid has sufficient renewable capacity to generate that hydrogen cleanly, natural gas could be useful as an interim source of 'blue' hydrogen – as long as the process includes carbon capture and storage (CCS) to keep the CO<sub>2</sub> out of the atmosphere.

"If we had to decarbonize all the natural gas in Europe and convert it to hydrogen, that would remove about 800 million tonnes of CO<sub>2</sub> per year or about 19 percent of current GHG emissions in Europe," says Nils Anders Røkke, chairman of the European Energy Research Alliance. "That's quite substantial."

international capital markets for backing projects that will result in planetary heating of over 4 degrees. At the same time the International Energy Association (IEA) calculated that offshore wind power could meet all the world's energy needs several times over.

Pretty soon hundreds of organizations, from local councils to steelmakers, automakers, supermarkets and national governments, were competing with each other to make ever grander promises of zero-carbon futures and environmental good behaviour.

But are these bold statements real commitments or just hollow public relations greenwash to tick the boxes of corporate social responsibility? And most important of all, if these promises are to be fulfilled, how is the carbon circle going to be squared, if at all?

"There is no doubt," says Tim Curtis, managing director of Ricardo Energy & Environment, "that there are enough natural resources to generate all the energy we need. But it is more complicated than that. Finance plays a big part, and so does government policy – these crucial factors impact on whether a technology can be developed, invested in,

applied, and to what level.

"There are very different policy frameworks in different parts of the world," he continues, "and it is my view that it is the policy agenda that will really drive things. Whilst technology can always be better, cheaper and more efficient, it's much more about the commitment from governments and international agencies that will make this happen."

### What does net-zero mean?

Achieving net-zero carbon effectively means ceasing to add to the stock of greenhouse gases (GHGs) already in the atmosphere – so any activities that still emit GHGs will have to be balanced by processes that remove those gases from the air. Natural carbon sink systems such as plants, trees, some soils and the oceans will of course continue to absorb GHGs, but their capacity to do so is limited and probably reducing. And the industrial CO<sub>2</sub> removal technology that will be needed to complement natural absorption mechanisms is in its infancy and is unproven at scale (see panel on page 22).

The scale of the challenge is vast. According to the Global Carbon Project some 55 gigatonnes (Gt) of CO<sub>2</sub> and other

GHGs are emitted each year by everything from farm animals and home fireplaces to power stations, blast furnaces and transport systems. To absorb this through natural processes would require an area 20 times the size of the Amazon rainforest, according to AP News.

Much has been made about the cost of tackling the climate crisis. Yet, argues Curtis, we need to look much further ahead than the next four- or five-year political cycle. "Yes, of course there is a cost of acting and investing. But what is the cost of not acting? It is 12 years since Sir Nicholas Stern said 'The evidence on the seriousness of the risks from inaction or delayed action is now overwhelming. We risk damages on a scale larger than the two world wars of the last century'. And the case now is even more compelling – we need to act now to mitigate the catastrophic potential impacts of climate change, and the huge future cost implications. It's challenging for the political policy agenda, I know, but the investment today is critical for the benefits we will see in 50 or 100 years' time."

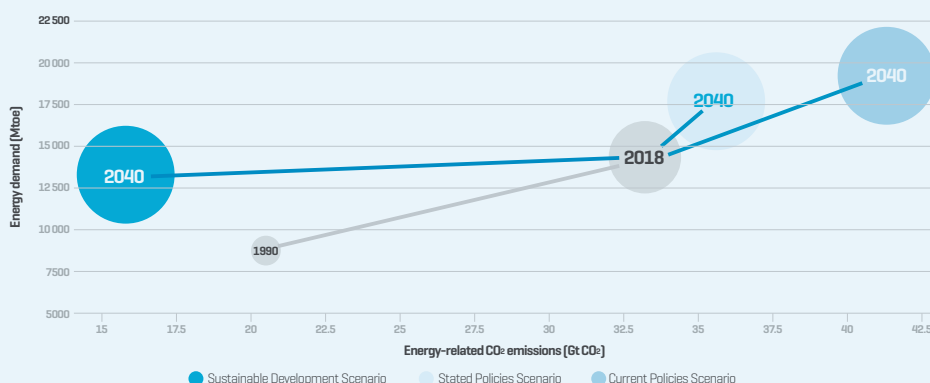
The 2015 Paris Agreement brought a measure of commitment between nations on jointly reducing GHG emissions, albeit with some major emitters jumping ship, and many others lagging on their agreed timescales; Europe is leading by example when it comes to putting pro-climate promises into law, giving some hope that other global players may follow, and technology advances across a scattering of industry sectors offer the hope of carbon-free or at least low-carbon alternatives for today's industrial processes.

But will all this be enough to deliver on the widely hyped zero-carbon targets for 2050 or even earlier?

"Historically," says Curtis, "climate change has not really been on the agenda at the board level of most corporations, and it has largely been ignored by the

**Global CO<sub>2</sub> emissions will increase rapidly (2040 circle on right-hand side of chart) under business as usual scenario, but even current climate policies will not be enough to stem demand and GHG output. Instead, the IEA's proposed sustainable development scenario (dark blue 2040 circle on left) stabilizes demand and halves CO<sub>2</sub> emissions**

World primary energy demand and energy-related CO<sub>2</sub> emissions by scenario



Source: IEA, 2019





finance sector. However, things are changing, and the Environment, Social and Governance (ESG) agenda has gained traction over the last couple of years, and this is beginning to unlock climate-related investment.”

Also, Curtis adds, “I think that a lot of the corporate response to date has been about compliance. With the increased

awareness of the ESG Agenda, and the impact of the Taskforce on Financial-related Climate Disclosure (TCFD), we are seeing major corporates and asset managers becoming concerned at the risks and opportunities as a result of climate change.”

His colleague James Harries, principal consultant, environmental evidence and

data for Ricardo Energy & Environment, concurs: “Lack of progress tends to be a failure of political leadership – set the right policy framework and the rest will follow.

“But also,” Harries argues, “it is a failure of individuals. Many of us understand the problem but still don’t take action to cut back on flights, car journeys, meat consumption and other carbon-intensive activities. Some people talk about the need to educate people, but even for people that understand climate change, cognitive dissonance can be huge.”

### The role of authorities

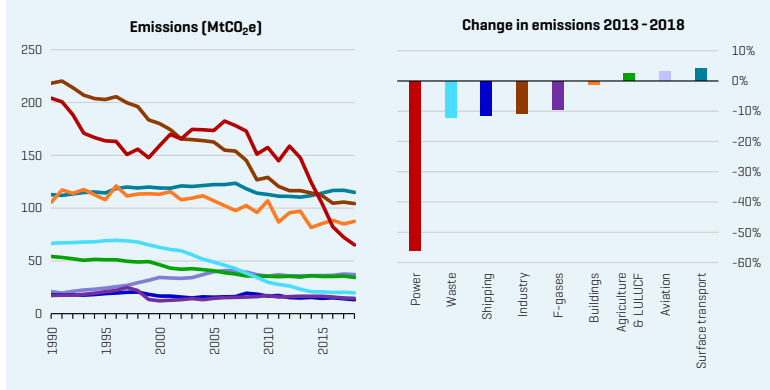
Greta Thunberg’s appeal to the UN summit could be seen as an urgent wake-up call to those with their hands on the levers of power and influence; a call to governments, NGOs, finance houses and industry regulators to work together. And thankfully, in recent years a new kind of linkage has emerged: an intermediary function that can bridge the divide between developed and developing nations – many of which find themselves on the front line of climate crisis effects.

These intermediaries, well connected with governments as well as in the spheres of technology and finance, can help prime the pumps for climate funding, establish targets and pathways, and play a co-ordinating role. And, as Curtis explains, Ricardo Energy & Environment is a leading player in these initiatives, initiatives that lie at the core of the calculations underpinning the 2015 Paris Agreement: “We’ve supported Nationally Determined Contributions (NDC) implementation in 17 countries including Bangladesh, Nigeria, Myanmar and Thailand – these are basically action plans to reduce their carbon emissions.”

Countries are encouraged to update their UN climate commitments in 2020,

**Greta Thunberg to the UN: “The popular idea of cutting our emissions in half in 10 years only gives us a 50 percent chance of staying below 1.5 degrees, and the risk of setting off irreversible chain reactions beyond human control”**

### Trends in UK sectoral GHG emissions



Source: BEIS (2019) 2018 UK Greenhouse Gas Emissions, Provisional Figures; BEIS (2019) 2017 UK Greenhouse Gas Emissions, Final Figures; CCC calculations.

Notes: The chart on the right-hand side shows changes in sectoral emissions between 2013 and 2018 for all sectors except for Agriculture, LULUCF, Waste and F-Gases which cover the period 2013-2017; buildings emissions in this chart are temperature-adjusted.

**Moving from coal to gas and renewables has dramatically reduced the UK's energy emissions since 1990 (left) but aviation, surface transport and agriculture are still increasing. Source: Committee on Climate Change**

## THE DECARBONIZATION HITLIST: INDUSTRY

GHG emissions from industry are dominated by the large, energy-intensive branches such as steelmaking, cement production, and the various forms of materials processing. Another significant and rapidly growing contributor is the ICT sector, whose server complexes are major energy consumers. Further complications are the substantial sunk costs in legacy plants and equipment worldwide, and the slow pace and high cost of renewal with updated technology.

Switching from dirty fossil fuels such as coal is already having a beneficial effect on both GHG emissions and air quality, but a major challenge will be to ensure that rapidly expanding economies such as India, China and Nigeria come onboard with this switch, too. Hydrogen could become an important player in a clean industry future and can in most applications directly replace natural or coal-derived gas. However, the cleanness of hydrogen would be

directly contingent on the availability of sufficient renewable energy for electrolysis or, as an interim condition, effective CCS provision to decarbonize hydrogen production from natural gas.

The Gupta steel empire, for instance, has set itself the target of 2030 to become fully carbon neutral across its activities.

Stretching the definition of industry to include agriculture and land management, significant changes will be required to achieve carbon neutrality; one of the key enablers in any such transition will be a big shift in human diet, away from high-impact foods such as meat and dairy, and towards more plant-based foods. In parallel with the eventual imposition of a moratorium on deforestation, this could lead to major reductions in GHG emissions from the farming sector, along with a win-win improvement in air, soil and water quality.

## THE DECARBONIZATION HITLIST: TRANSPORT

Transport is the sector where the moves towards sustainability are most clearly visible. The migration to electric power for private cars is just beginning, aided – for once – by a certain amount of clarity at the political level on the phase-out of combustion-engined vehicles. But though battery technologies are now well established, the battle is not yet won: most of the legislative developments have so far been confined to Europe, and satisfactory solutions for commercial vehicles are some way behind.

In the rail and urban mobility subsectors it is safe to assume that electricity and hydrogen will become the predominant energy vectors, though the now-familiar adage that a battery vehicle is only as green as the

electricity it runs on will once more come back into focus.

Shipping and aviation continue to present a dilemma. Aviation is growing unsustainably but probably represents the best potential application for expensive synthetic liquid fuels, while the turnover in shipping fleets is very slow and changes will take a long time to bring benefits. Potential green fuels could include batteries for short-haul ferries and green hydrogen and ammonia for longer voyages. In addition, both sectors are still relatively unregulated and untaxed – a disincentive to the application of clean technologies.

→ taking into account outcomes and developments in the intervening period. Though technologies have certainly moved on since 2015, the evolution in climate finance is just as significant, as Tim Curtis again explains:

“With the Climate Finance Accelerator approach, Ricardo’s experts have been able to bring together international financial institutions, government aid funding, banks and the countries’ governments. We see that collaboration and a ‘blended finance’ approach as a very significant part of the future.”

### Principal sectors to decarbonize

The unlocking of climate finance through these new international mechanisms has the potential to kick-start a wide range of programmes across an even broader spectrum of nations. Many vulnerable island states, for instance, are already leading the way on reducing their own emissions but at the same time urgently need to adapt to the effects of climate change, while for industrial nations a major priority is to help mitigate the amount of GHGs emitted. And it is with the latter that the sectoral approach comes into

play, with technical and organizational developments offering significant reductions in emissions of all types.

The most important sector in this context is without doubt that for generating electricity and producing heat. However, Ricardo consultancy and engineering teams are active in almost every field, and in our ‘hitlist’ panels we take a quick tour of some key sectors to outline the principal issues involved and the steps that will be required to achieve a controlled descent in GHG emissions towards a 2050 zero-carbon goal.

### Co-benefits of decarbonization

The recent air quality emergency in Delhi provides a graphic illustration of how climate change – and especially global heating – can exacerbate the effects of existing pollution in densely populated areas, sometimes with tragic consequences. Air that is drier and hotter, and which remains static, tends to trap local pollution, especially particulate matter.

November’s report from the Lancet Countdown, examining the impact of climate change on human health, sounds an even more alarming note but also

advises that climate mitigation policies would have almost immediate beneficial effects on health.

A lot of the actions to address air quality will be the same as the ones that are needed to address the climate emergency, adds Ricardo’s James Harries. These might include transport measures such as electric cars and vans, hydrogen fuel cells for HGVs. “So it will be important for local authorities, etc, to take a holistic approach and to consider and accurately measure the potential co-benefits of climate actions,” he notes.

### Conclusions

Whatever the timing for the commitment, even if it is as late as 2050, reaching net-zero carbon is a formidable task and will entail massive disruption to our lifestyles, how we live, how we travel, and what we eat.

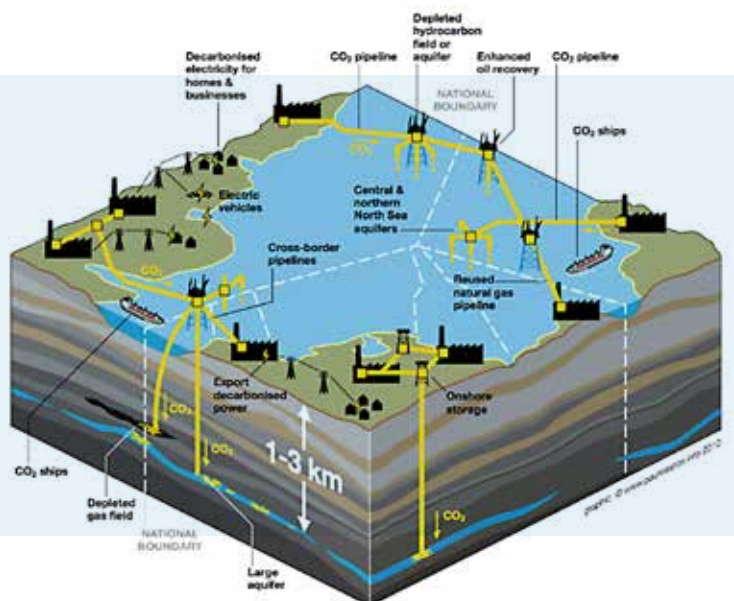
“Yet,” asserts Harries, “achieving net zero is definitely theoretically possible, and we can show that the technologies and other measures exist to deliver it. But the question is how fast we can realistically move, and at what cost.”

The UK Climate Change Committee (CCC) is also clear on what is feasible:

## Carbon Capture and Storage (CCS)

The idea of negative emissions technologies (NETs) appeals to those who want to reduce atmospheric CO<sub>2</sub> concentrations but prefer to keep disruption to existing industries to a minimum. How much we will be able to rely on NETs depends on timeframes. The paradox is that the earlier a net zero target, the more you need NETs but the less you can rely on them. Taking a zero-carbon target of 2030, NETs are not likely to help as governments estimate CCS will come onstream during the 2030s. For 2050 it is easier to envisage a role for CCS – indeed, the CCC says it is a requirement not an option. Nevertheless, debate continues over how much CCS can do, and there is uncertainty around costs and feasibility.

Source: Element Energy [2010], One North Sea  
(<http://www.element-energy.co.uk/2011/01/ccs-potential-in-the-north-sea/>)





## Tim Curtis is managing director of Ricardo Energy & Environment, and is based in London



### Which sector is top of your hit-list for overall decarbonization?

If you're looking at priorities, it absolutely has to be the energy sector. Energy is responsible for over 70 percent of global GHG emissions: it's such a huge part of the overall picture that this is the place to focus first. Electricity and heat production are the biggest sector within this – especially in the UK where

decarbonizing domestic heat is the number one challenge because of our inefficient housing stock.

### Looking ahead, which nations will be the big emitters?

The World Resources Institute calculates that the world's top three [GHG] emitters [China, the US and the EU] contribute 14 times the emissions of the bottom 100. Those are clearly the places to start, but that's where you get into the challenges of the political situation. A lot of our work has been supported by the international financial institutions in other countries, and increasingly in cities. A key part of our work has been country climate commitments (NDCs) and also city action plans, looking at where their emissions come from, how they can take action, and where the best place is to start – industry, energy production, housing and so on. It all depends on the context and we can help them understand the data and where to invest in order to have the biggest impact.

### How influential is Ricardo in the global picture?

For the last five or six years we have been proactive at each of the UN climate conferences: we have an awareness of what we bring to the global debate and it particularly comes down to these NDCs that we work on for individual countries. [Our work] is also increasingly getting into the finance agenda as well. We've begun to work on what we call Climate Finance Accelerators, and we are able to bring together international financial institutions, government aid funding, banks and the countries' governments. We act as a facilitator for funding streams from different sources to provide a budget to meet the

requirements that we are indicating in the NDC plan. We see that as a very significant part of the future.

### How can consultancies such as Ricardo be most effective in accelerating progress towards decarbonization?

We have over 500 consultants in the Energy & Environment team who cover a very wide range of skill sets across issues surrounding decarbonization. Yes, it's energy – but it's also water, waste, sustainable transport. We have the people who understand a wide range of sectors and what the solutions might be for those sectors. That breadth of knowledge that we have, combined with the depth of our scientific expertise, is the key that we have, and which others don't.

### Going back to energy, is green hydrogen the dream energy vector that some suggest?

This is a bit of a cliché, but there is no silver bullet and it will be a combination of technologies and approaches. It will be very closely linked to government regulation and incentivization. Whilst of course there are benefits of more efficient, impactful and cheaper technology, and we are working on a lot of technology and innovation projects, at the highest level we are limited by the [lack of] commitment and the slowness of reaction globally – not any individual country or company. You're always going to move at the pace of the slowest. We don't see enough urgency of action, even though the climate emergency issues are out there, and we've got much higher awareness.

### Are there areas that you feel have been overlooked in the debate so far?

Yes, we know pretty much what actions we can take to impact direct emissions, but there is much less awareness of embedded emissions – for example the carbon in plastic packaging and the lifecycle impact from all aspects of consumption. Also, I think that a lot of the corporate response to date has been about compliance. With the increased awareness of the ESG Agenda, and the impact of the Taskforce on Financial-related Climate Disclosure [TCFD], we are seeing major corporates and asset managers becoming concerned at the risks and opportunities as a result of climate change.

"it is technically possible based on current consumer behaviours and known technologies" [for the UK] to achieve a net-zero target by 2050. Even so, Ricardo's Tim Curtis adds an all-important rider: "Net zero may be more challenging in other countries, but that doesn't alter the fact that we can achieve huge reductions, globally, from current technologies. The socio-economic conditions and political will are more significant barriers than the technology."

Some governments and NGOs are aiming for 2040, 2030, or even 2025; many of these targets are likely to be unachievable. But does that matter?

Ambition and communicating the sense of urgency are important motivators, and those going fastest will help shift the centre ground to spur others into action.

But while individuals and local groups may be ready for change, inertia at higher levels continues to stifle initiative. Just 13 of the world's 132 largest energy producers have made any commitment to reduce their GHG emissions to zero, according to a study conducted by the London School of Economics's Grantham Research Institute on Climate Change, and the CCC warns that the UK's role as a genuine climate leader now rests on tangible action – summing up the stasis

that seems to be paralyzing so many administrations.

Yet, says Curtis, the signs are increasingly encouraging. "The mood has changed dramatically in the past six months, and there has been a breakthrough in the investment community. In the private sector, climate is going mainstream, and fund managers are now asking us where do we start, and what do we do? I love those conversations, because I know we have a pool of extremely talented consultants as well as the ability to understand our clients' needs and then articulate clear proposals for action." 

## THE DECARBONIZATION HITLIST: OTHER SECTORS

Energy use by the residential sector is another candidate for efficiency improvements: some studies estimate that one-fifth of global energy demand goes into heating and refrigeration. Already, in North America, residential cooling absorbs as much energy as space heating, and the position

will worsen as weather extremes become greater and more frequent.

Taking the UK as an example, Ricardo's Tim Curtis notes that decarbonizing domestic heat is a major challenge because of the country's inefficient housing stock.

# RQ RICARDO NEWS

Latest developments from around the global Ricardo organization

## Innovative EV rapid-charging trial



An innovative project known as DC Share will develop and test a novel solution that shares capacity across existing AC electricity distribution network substations in order to enable increased numbers of high-power electric vehicle (EV) chargers to be connected to the network at lower cost.

The DC Share project has seen Western Power Distribution (WPD) and Electricity North West Limited (ENWL) join forces with Ricardo to use latent capacity in distribution networks to

power charging hubs.

DC Share has been awarded funding by the UK energy market regulator Ofgem (the Office of Gas and Electricity Markets) through the Network Innovation Competition Project. The project aims to use spare capacity in distribution networks, something that is difficult to access using traditional means. The DC Share project will trial a novel approach to supplying rapid charging hubs, using power electronics to extract power from existing substations and distributing this

to rapid EV charge points via a new high-capacity DC cable network.

The location of the rapid chargers will be an important factor in the successful widespread uptake of EVs and should be dictated by user requirements rather than network constraints. To ensure charger availability for multiple users, rapid chargers are expected to be deployed in hubs, meaning that significant amounts of power will be needed in one location. While an existing substation might be able to connect one or two rapid chargers, if they are required at scale, network reinforcement is likely to be needed. DC Share will facilitate the connection of rapid charging facilities in locations where they are required by users, using latent capacity in the surrounding networks to minimize the cost of connection.

The trial will explore the comparative benefits of a DC network, where power flows can be actively managed, and fault level contained, over the traditional approach of AC network reinforcement. The DC Share project will lay a new high capacity DC equalization cable network, which will balance demands so that transformers experiencing heavy demand receive support from those that are more lightly loaded. This approach enables uncertainty in demand to be managed more effectively, optimizing power flows in real time to react as needed.

## Improving tactical wheeled vehicle readiness

Ricardo's North American defence team, together with the National Center for Manufacturing Sciences (NCMS), has embarked on a collaborative project using the concept of condition-based maintenance to demonstrate readiness improvements for the U.S. Army's tactical wheeled vehicle fleet.

Commencing in September 2019, 30 tactical wheeled vehicles participating in operational training exercises at Ft. Irwin, CA, are being outfitted with devices that will collect data on vehicle health, usage, and operating conditions from more than 80 different onboard sensors. Working in collaboration with the Army's Project Manager Transportation

Systems (PM TS) and Army Futures Command, this data will be provided to the army's maintainers and engineers in order to help improve the maintenance of ground vehicles.

The objective of the 18-month pilot project, led by PM TS, is to showcase technologies and analytical capabilities that enable predictive maintenance – the concept of monitoring the vehicle's condition, configuration, and operating history simultaneously to predict when failures are likely to occur. This approach permits more proactive and timely maintenance actions, thus avoiding downtime associated with the vehicle from being taken out of service for repair.







## Sustainable development 'depends on biodiversity'

A new study, co-authored by Ricardo and published in Nature Sustainability, makes clear the breadth of ways in which biodiversity can contribute to achievement of all 17 of the UN's Sustainable Development Goals (SDGs), thus helping underpin overall sustainability goals.

The authors of Biodiversity's contributions to sustainable development [Nature Sustainability, 25 November 2019] note that despite biodiversity's wide-ranging benefits for people, it continues to decline at an alarming rate. Ricardo Energy & Environment's Richard Smithers, the study's co-lead author, warns: "We are currently fulfilling our wants and desires in ways that mean future generations will be unable to meet their basic needs."

The study highlights that complex links between biodiversity and sustainable development may not only lead to them being overlooked but also to well-intended but misguided actions. For instance, in comparison with developing countries, many developed countries thrive economically despite having less biodiversity. Yet this paradox can be explained when one realizes that such countries often sustain their development by benefiting from

degradation of less-developed countries' biodiversity. For example, the UK was the world's second largest net importer of forest products in 2015.

"Such coupling of socio-economic and environmental interactions means that national, transboundary and international actions are needed to sustain biodiversity and development globally," says Associate Professor Malgorzata Blicharska, the study's other co-lead author, and a member of the Natural Resources and Sustainable Development Programme at Uppsala University, Sweden. "People benefit from biodiversity in so many ways that are under-appreciated or ignored. For example, a diversity of pollinators ensures crop pollination, and a third of global food production is dependent on them; also, microorganisms contribute to waste management, and many species have inspired people to develop new products and ways of doing things."

"We hope that increasing people's awareness of biodiversity's many contributions to sustainable development will encourage policymakers at all levels to bring biodiversity considerations into the mainstream across a broad range of development sectors and thereby halt and reverse biodiversity loss," adds Smithers.

## Multiple award success for Ricardo

In November this year Ricardo received recognition in the areas of innovation, manufacturing and apprentice training. The first award was presented at the 2019 Adur and Worthing Business awards, an annual event celebrating the achievements of businesses in this region of Sussex, hosted this year at the Pavillion Theatre in Worthing. Ricardo was named as Business Of The Year in the Innovation category.

This recognition was followed later the same month with a further two accolades at the Made in the South East awards, hosted by Insider Media at the Sofitel London Gatwick. These awards recognize and reward manufacturing companies based in this UK region that have demonstrated success in innovation, product development and revenue growth in either domestic or overseas markets.

Ricardo's manufacturing division, Ricardo Performance Products, was recognized with the prestigious title of Manufacturer of the Year at the ceremony. The award reflected some significant developments in capability and capacity during the past year. These include the completion of a multi-year development programme to support prototype batch assembly using the main production line facility and without any disruption of series supply.

Development of the end of line's 'Break In, Pass Off' facility was also completed during the year, doubling the previous capacity to deliver road-ready engines to the customer's line-side, along with a continued expansion of the global supply chain of spares and sub-assemblies scheduled from the same Ricardo facility.

In parallel with the significant recognition for the company, Ricardo's Andrew Kershaw was also named as Apprentice of the Year at the awards ceremony, recognizing his contribution to the manufacturing business throughout the year.

## UK trials of wheel-rail adhesion technology



Ricardo Rail's Track Consultancy team is closely involved in a trial taking place on the UK rail network that could improve future service performance during the autumn. Leaves

that fall on rail lines can become crushed under the wheels of passing trains, leaving a hard residue on the railhead surface. When this is combined with a little moisture such as morning dew, it can result in a very low level of adhesion between wheel and rail, adversely affecting train braking and acceleration performance and ultimately, risking damage through flattening of the wheel surface.

A response long used by the industry has been to deliver sand from the vehicles directly onto the rails to improve wheel/rail adhesion. This month's trial, undertaken by Ricardo, looks to see if that approach can be improved upon. It will build on research initiated by the UK's Rail Safety and Standards Board (RSSB), looking at whether it might be possible to optimize the distribution of sand to further enhance stability on wet and slippery tracks.

The UK network is currently developing an amended autumn timetable on certain routes that introduces longer gaps between services, and requires drivers to reduce speed to allow for longer stopping distances and prevent trains overrunning station platforms. The new technology is expected to pave the way for vehicles equipped with Double Variable Rate Sander technology to get much closer to performing as consistently in low adhesion conditions as they do at other times of the year.

## Ricardo helps JCB into the record books - again

It can be revealed that Ricardo played a crucial role in the development of JCB's speed record breaking Fastrac tractor. As shown on UK TV audiences on Channel 4's documentary, Guy Martin: The World's Fastest Tractor, which aired on Sunday 17 November, motorbike racer, truck mechanic and TV personality Guy Martin powered the tractor to a new Guinness World Records speed record with a speed of 135.191 mph (218 km/h).

The achievement comes after JCB set the British Record for the fastest modified tractor at Elvington Airfield near York in June 2019 with a tractor designated 'Fastrac One.' It reached a speed of 103.6 mph with Martin in the driver's seat. JCB then embarked on an ambitious plan to break its own record and developed 'Fastrac Two' - which was 10 percent lighter, more powerful and even more aerodynamic. Also driven by Martin, Fastrac Two hit a peak speed of 153.771 mph on its way to clocking a record average of 135.191 mph.

Engineering a JCB Fastrac agricultural tractor, normally weighing around 8.5 tonnes, to achieve speeds of over 100 miles per hour was something of an unusual challenge for Ricardo. Yet the record-breaking challenge was not without precedent. Many of the same Ricardo team members were responsible in 2006 for the development of the two 750 hp engines and supporting systems of the successful JCB Dieselmix Land Speed Record car.

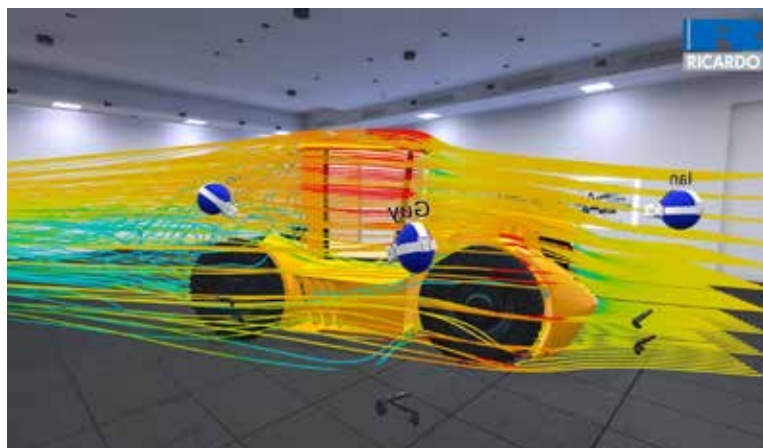
Ricardo used cutting-edge digitalization methods, including virtual reality (VR) for design reviews, enabling engineering teams across multiple sites to collaborate quickly and in real time, without having to travel extensively. In particular, creating a 'virtual wind tunnel' helped Ricardo, JCB and Williams engineers to collaborate remotely on aerodynamic optimization: identifying areas where work was required to avoid the creation of significant drag.

Aerodynamic optimization was further enabled by Ricardo's



suite of proprietary virtual product development tools. Ricardo VECTIS software was used to perform computational fluid dynamics (CFD) simulations of the external skin of the tractor. Further advanced software tools used included Ricardo's IGNITE powertrain optimization suite and WAVE gas dynamics simulation package for air system development. Routinely used to optimize products for customers, these advanced software products enabled the Ricardo team to develop the JCB 7.2 litre, six-cylinder engine to meet the power and torque targets for this project.

**Fastrac Two with Guy Martin** [above], and shown with CFD predicted air flow using the Ricardo Virtual Reality system [below]



## Water aims for net zero

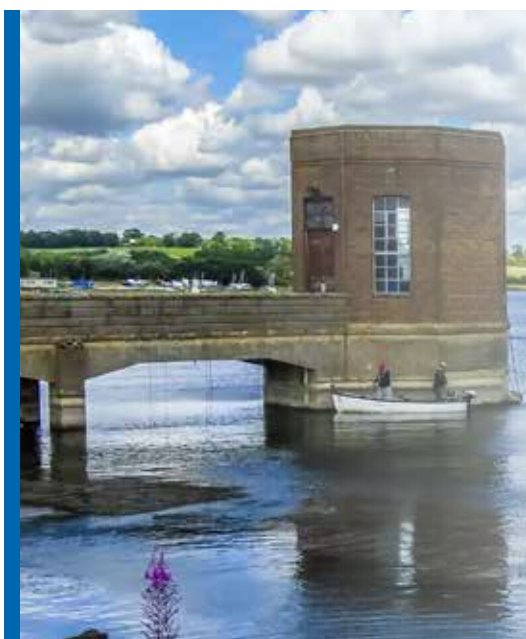
The water industry is the first industrial sector in the UK - and one of the first major sectors in the world - to commit to a carbon-zero future by 2030.

As the fourth most energy-intensive industry in the UK, the water sector directly contributes around 5 million tonnes of GHG emissions each year. As well as the immediate impact of carbon reductions, the industry intends to share its learnings to help other major energy-using industries to deliver their own plans.

To assist with this net-zero ambition, Ricardo is collaborating with consultancy Mott MacDonald

on behalf of Water UK to develop a comprehensive action plan detailing the measures the industry will deploy to achieve zero carbon emissions over the next decade. The project will draw upon Ricardo expertise for the plan, to be published in March 2020, followed by a detailed report in the summer.

Progress on the goal will be independently assessed each year, with key milestones reported publicly. Individual companies within the water sector will use the action plan to inform their own detailed approaches to meeting net zero across the industry by 2030.







# Subscribe to benefit from:



**Industry news** – the latest in technology, innovation and sustainability from across the world



**RQ viewpoints** – industry opinions from Ricardo experts in every sector from automotive and defence, to environment and rail



**Interviews** with leading technology developers, senior executives and industry thought leaders



**In-depth features** revealing the industry-leading projects in the Ricardo portfolio



**Ricardo news** – latest developments from across Ricardo's global organization

**Visit:** [www.ricardo.com/RQsubscribe](http://www.ricardo.com/RQsubscribe)

Copyright © Ricardo plc | V1 18C U



Creating a world  
fit for the future



# EMLEG

Emissions Legislation Database



## Stay up-to-date in the rapidly evolving world of emissions legislation

**EMLEG is an online service that contains an explanation of emissions standards and CO<sub>2</sub> emissions/fuel economy regulations that are taking place globally.**

This subscription tool is easily accessible on mobile or desktop. The database is continuously updated with the latest developments in over 50 countries worldwide, including the EU, US, China, India, Japan, Brazil, South Korea, and more. EMLEG covers passenger cars, light duty commercial vehicles, heavy duty vehicles, motorcycles, non-road engines and vehicles and marine engines.

**Enquire today and sign up for a live demo!**

Email: [emleg@ricardo.com](mailto:emleg@ricardo.com) Tel: +44 (0)1273 455611

[www.ricardo.com/emleg](http://www.ricardo.com/emleg)