Ricardo Quarterly Review
Spring 2021

RQ

A focus on the latest in innovation, sustainability and technology

RICARDO

The green industrial revolution
How governments, industries and organisations are navigating routes to net zero

Marque of respect
BSA is back – with plans for electric motorcycles

A WORLD TRANSFORMED

How Ricardo is rising to the global challenge of change

RQ

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RICARDO

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RQ NEWS

Latest developments from around the global Ricardo organisation

Reducing electric vehicle battery failures

Funding for research project to improve performance

Ricardo has won funding from the Office of Low Emissions Vehicles (OLEV), in partnership with Innovate UK, for a research and development (R&D) project to improve electric vehicle (EV) battery life, performance and resilience.

- First, Ricardo will propose novel data storage methods on a connected battery management system, exploring techniques for data compression without degrading fidelity.
- The team will then develop innovative algorithms, combining physics-based modelling and data-driven techniques to generate insight into the battery health.
- Finally, the team will use these algorithms to derive techniques to automatically update the battery management system calibrations that will be provided to vehicles over the air.

From previous experience in R&D programmes on connected vehicle platforms, such as the ConnectHEV technology demonstrator, Ricardo's engineers appreciate the power of digital services to extract insights from the large datasets generated by connected vehicle fleets. The company's vision is for advanced monitoring and prognostics services to reduce EV battery failures in the field and extend battery life, which is the focus of this piece of research.

Tools to virtually represent vehicle fleets will provide data for the connected battery management system test platform

The team will develop tools to virtually represent vehicle fleets, which will then provide data for the connected battery management system test platform. The team will address information, data and software flows to and from the battery system, while also focusing on battery monitoring and the development of prognostics algorithms.

"For a number of years our R&D has delivered technologies which are helping to accelerate the adoption of electric and hybrid vehicles," says Richard Gordon, Ricardo's Head of R&D. "We are confident that this project will be a significant building block in helping manufacturers leverage simulation, virtual calibration and trusted data sources to improve EV battery performance. This in turn will reduce long-term warranty costs and build consumer confidence in electric or hybrid products."

Devon targets net zero

Famed for its coastline and cream teas which attract millions of tourists each year, Devon nonetheless faces the same issues as many other parts of the UK: economic inequalities, poor public health, the need for more active travel, variable air quality and fuel poverty, together with the challenge of transitioning to clean technologies.

In response to the UK government's legal commitment to achieve net zero CO_2 emissions by 2050 and recently announced target of reducing carbon emissions by 68 per cent by the end of this decade, a Net-Zero Task Force has spent the last year developing a Devon Carbon Plan that aims to deliver a net-zero future for the county. The 15-strong group comprises experts in renewable energy, transport, planning, waste and the environment, and includes Ricardo Head of Sustainability Hannah Lawrie.

The task force has worked alongside 25 organisations, including local authorities, emergency services, businesses and voluntary groups, who make up the Devon Climate Emergency Response. Residents were able to contribute ideas at the evidence gathering stage and comment during a 10-week consultation phase which ended in February.

"We have been able to create a collaborative roadmap that will lead not only to a more sustainable future for the county but will also enhance the lives of everyone who lives there," says Lawrie.

New powertrain software released

Innovative features for fuel cell, electrified and conventional vehicles

Ricardo's final 2020 release of powertrain design and optimisation software has brought a wealth of new features and capabilities offering speedier simulations and improved productivity.

A notable inclusion in the 2020.4 release is a new fuel cell library within the complete vehicle system modelling and simulation package IGNITE. This feature allows software users quickly to investigate and compare different design and powertrain system architecture strategies.

There are also major enhancements to the real-time performance simulation package WAVE-RT, with higher fidelity models and improvements to the process and run time of simulations. Together, these innovations underscore Ricardo's continued position as a leading source of efficient calibration solutions for the automotive, powertrain and transportation industries.

"This release shows our commitment to provide the very best in simulation capabilities," says Ricardo Software Managing Director Kimberly Matenchuk, "as required by those developing fuel cell, battery and hybrid vehicle powertrain systems, as well as those pushing the boundaries of fuel efficiency and low emissions in combustion engines."

↳ For more details of the full range of upgrades available in the Ricardo Software 2020.4 release, together with information on product licensing, visit software.ricardo.com.

Transport location data project supports cleaner journeys

Ricardo has received funding from the Geospatial Commission in partnership with Innovate UK to enhance transport location data so that hybrid electric vehicles (EVs) can intelligently modify how they operate. The company was one of the winners of a national transport location data competition.

Brighton & Hove Buses in East Sussex operates the UK's first zero-emissions, geo-fenced bus fleet. Its 54 buses have been fitted with smart, on-board technology, designed in a collaboration between BAE Systems and bus manufacturer ADL, which enables them to sense when they are in pre-defined areas and automatically switch to zero emissions mode. To read more about Brighton & Hove Buses' fleet, see page 20.

Ricardo's study will examine the benefits of adapting existing geo-fenced areas to respond dynamically to changes in air quality. It will also explore extending the technology to privately-owned fleets of taxis and delivery vans so they could also switch to EV mode in ultra-low emissions zones.

Immersion cooling battery tech wins award

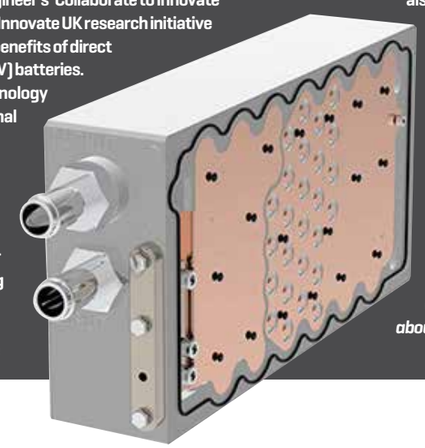
A research and development consortium led by M&I Materials and featuring Ricardo and Warwick Manufacturing Group, part of the University of Warwick, has won The Engineer's 'Collaborate to Innovate' Award in the automotive category. The Innovate UK research initiative is designed to explore and validate the benefits of direct immersion cooling of electric vehicle (EV) batteries.

The immersion cooling battery technology project, i-CoBat, deploys a novel thermal management system for EV batteries using a biodegradable dielectric fluid called MIVOLT. This allows for faster charging than conventional systems and a higher performance battery.

The technology will make EVs better performing, safer and cheaper, helping to accelerate adoption of electrified transport.

The total cost of the battery and the impact on the vehicle can be reduced by using immersion cooling, thanks to the lower cost of the battery pack. Using immersion cooling also provides safety enhancements: it can mitigate and stop thermal runway and fire propagation.

Because the technology has been designed to be lightweight, it can easily be used in the aerospace industry. Indeed, the Ricardo proprietary design approach of partial immersion cooling is currently being used in the propulsion module for the next-generation electric aircraft Ricardo is helping to develop with consortium partners for the InCEPTion project *(see news story overleaf)*.



To read more about Ricardo's role in the collaboration, visit: automotive.ricardo.com/about-automotive/news-and-blogs

Ricardo helps next-gen electric aircraft take off

Ricardo is part of a seven-strong UK consortium from industry and academia developing a next-generation, integrated propulsion module with zero tailpipe emissions to enhance aircraft performance while reducing operating costs.

The consortium was founded by Bedford-based Blue Bear Systems Research and will be working on a two-year project supported and co-funded by the UK's Aerospace Technology Institute and Innovate UK.

The project – Integrated Flight Control, Energy Storage and Propulsion Technologies for Electric Aircraft (InCEPTion) – will deliver a highly power-dense, quiet and efficient propulsion module with zero tailpipe emissions. It will be a scalable design and the first in a range of products that can be used for aircraft weighing less than five tonnes.

"Our engineers excel at bringing together novel, complex, clean propulsion and energy solutions, taking a whole lifecycle carbon neutral approach to minimise environmental impact," says Richard Gordon, Ricardo's Head of Research and Development.

InCEPTion will deliver a highly power-dense, quiet and efficient propulsion module with zero tailpipe emissions

"We are expanding efforts to apply our world-leading technology solutions, honed in the automotive and industrial sectors, to the aviation sector where there is a real need for proven technologies which can improve efficiency and performance as Original Equipment Manufacturers work towards net zero emissions."

On-track machines receive approval

After almost five years' work, Ricardo's rolling stock design team have received London Underground's design acceptance of the Kirow KRC250 Rail Crane and Switch Tilting wagons. The wagons will help accelerate track replacement works on the 'Sub-Surface Lines' (SSL) network – four lines that also operate above ground towards London's outer suburbs.

The team had to show that the machines met the requirements of the London Underground standard for on-track machines. Although switch tilting wagons have operated on the UK national network for several years, various design modifications were required for a model that must fit within the SSL network's tighter confines. A key challenge was that the wagons needed to be approved for use on both the national and London Underground networks.

The project began in 2015 with Ricardo's teams working with London Underground and client Kirow Ardelt, based in Leipzig. Since then, more than 14,000 hours have been spent developing evidence to show the required compliance. Ricardo Certification, an accredited independent business within the Ricardo group, managed the sign off process with London Underground.

Electrified Propulsion Research Centre opens

Located at Ricardo's Shoreham Technical Centre in West Sussex and designed to support existing work in powertrain optimisation and electrification, the new £5.5 million centre will enable the research and development of the next generation of electric vehicles (EVs) from component level subsystems to fully integrated powertrains.

The centre will enhance Ricardo's expertise in test and development and significantly increase the range of services and solutions across all platforms and applications in EV development available to global customers.

The facility will be underpinned by digital engineering and simulation technology, including digital twins which will replicate the physical environment and will be refined with actual test data. It is designed to integrate seamlessly with the company's digital analysis, simulation and calibration accelerators so that vehicles can be developed holistically using fully optimised technology solutions.

The result will be customer solutions which are 'greener' because they are less energy- and resource-intensive and remove risk from development through more efficient, faster digital techniques.

E-fuels better focused on aviation and shipping than road

A new Ricardo report shows that the use of synthesised e-fuels should be prioritised for shipping and aviation, ahead of road transport where other forms of electrification are more effective.

'Renewable electricity requirements to decarbonise transport in Europe with electric vehicles, hydrogen and electrofuels' was produced on behalf of transport campaign group Transport & Environment. It investigates whether a number of decarbonisation pathways are achievable within the limits of supply-side constraints such as the renewable energy generation potential of the EU.

The report's key messages include:

- Direct electrification should be the focus for road transport, wherever possible, as it is the most efficient path to decarbonisation.
- Road transport will decarbonise more rapidly than shipping and aviation to 2030, but to decarbonise shipping and aviation will need significantly more renewable electricity to produce the required levels of e-fuels by 2050 (projected to be 30 per cent of the total).
- Policy decisions about zero-emission heavy-duty trucks in the early 2020s will have significant ramifications for electricity demand by 2030 and 2050.

↳ The full report can be downloaded at: transportenvironment.org/publications.

Orient and Ricardo developing innovative battery management system

A next-generation energy storage system designed, developed and manufactured by Orient Technology will incorporate elements of Ricardo's advanced battery management and control algorithm technology.

The company's wide-ranging experience in hybrid and electric vehicle battery pack development has led to the partnership with the Singapore-based business.

Ricardo's battery pack development support ranges from applying new cell chemistries and battery architectures to designing and building prototype packs and supporting customers through to full-scale manufacturing implementation.

Among the key areas of Ricardo expertise that Orient Technology will use are in the incorporation of advanced battery state and parameter prediction: this will be based on Ricardo-developed condition monitoring, modelling and control algorithms that have been proven robust across different cell chemistries and in challenging applications.

"Our experience in the development of energy storage means we can offer expert assistance in bringing forward further battery system innovations," says Ricardo Asia President Gary Tan. "We can deploy our virtual engineering toolset to this challenge, which allows for rapid design, simulation and analysis of a wide range of battery design concepts."

VIEWPOINT

Why electric vehicles will be the 'new normal' by 2030

Sandra Roling – Head of Transport, The Climate Group

In November, the UK will host the UN's 26th Climate Change Conference – the first time it has been held in this country.

Known as COP26 (ukcop26.org), the Conference will be a major milestone for international climate action, where governments around the world come together to assess their progress since the landmark Paris agreement of 2015, and to fill the ambition gap that still remained at the end of those negotiations.

No less important is the fact that the UK Government has identified clean transport as one of five priority themes for its Presidency. The transport sector accounts for around one-quarter of global energy-related greenhouse gas emissions; in the UK and US it is the single largest emitting sector.

Our goal at The Climate Group is a world of net zero carbon emissions by 2050. We focus on systems with the highest emissions and where our networks have the greatest opportunity to drive change.

One of our areas of focus is making electric transport the 'new normal' by 2030. Electric vehicles (EVs) can cut millions of tonnes of emissions per year, as well as helping to address transport-related air and noise pollution and issues relating to public health.

In the run-up to COP26, we'll be working with the UN High-Level Climate Champions and other partners to run a leadership campaign raising awareness, ramping up ambition and driving action on zero emission road transport. This will be particularly focused on the role that 'non-state actors' – those stakeholders that are not national governments – can play.

Among our initiatives is EV100, in which more than 100 leading companies across 80 markets have committed to transition their fleets to electric and install EV charging for staff and customers by 2030. That's nearly five million vehicles electrified by the end of the decade – more than the number of vehicles sold in Germany every year.

In our new progress and insights report, entitled 'The EV revolution is here' (available at: theclimategroup.org/ev100-annual-report-2021), we comment that many people might have expected 2020 to be something of a 'lost year' for climate action due to the turbulent impact of COVID-19 on businesses and governments.

"The transport sector accounts for around one-quarter of global energy-related greenhouse gas emissions; in the UK and US it is the single largest emitting sector"

On the contrary: more than half our members have either continued on the same trajectory towards their 2030 EV pledges or even quickened the pace. They recognise that the climate crisis is just as urgent as it was prior to the pandemic. The need for action hasn't changed.

In just a year, the number of EVs deployed by our members has risen to 169,000 – over twice the number from last year. These businesses are not just making progress on their fleets but charging infrastructure too. By using their property portfolios – their offices and stores – they've installed nearly 16,900 charge points to date that support staff and customers alike in going electric.

These statistics give us confidence about our 2030 ambition. As vehicle choices grow and upfront costs fall, it makes sense for every organisation to future-proof its operations against regulatory and reputational risk. With a large part of the global vehicle fleet purchased by companies, businesses have a crucial role to play in driving the transition to a clean transport future.

10 TRANSFORMATIONAL LEARNINGS FROM A YEAR OF UNCERTAINTY

The last 12 months of enforced restrictions and disruption have placed immense strain on businesses and economies. *RQ* explores the insights and innovations that have helped Ricardo, its partners and customers respond positively to 'business as unusual'.

It's now 12 months since the World Health Organisation declared coronavirus a global pandemic and national lockdowns were introduced to flatten the curve of infection and protect essential services.

Aside from the human tragedy wreaked by COVID-19, the most severe health crisis in modern history has compelled organisations to reconfigure working practices, review employee well-being, reassess the needs of customers and recognise emerging threats and opportunities.

A key to navigating this unprecedented period is the concept of 'adaptive capacity', which refers to the flexibility of an organisation to operate effectively and successfully in unstable and fluctuating environments.

During 2020, it became clear that companies that had, first, conducted scenario planning and, second, scaled their digital capabilities prior to the pandemic were best placed to ride out the storm.

RQ magazine reported last summer (2020 Q2 issue) on Ricardo's own scenario planning activity, a key component of the company's long-term strategy development.

In addition, Ricardo's digital-first approach had equipped the business with the flexibility to work remotely and without interruption. The creation of 2,900 'new offices' in the homes of employees together with cloud-based computing and secure connectivity has enabled Ricardo and its operational ecosystem to 'embrace uncertainty' while facilitating innovation in the product development cycle.

01 YOU CAN'T PREDICT THE FUTURE BUT YOU CAN CERTAINLY PLAN FOR IT

"Scenario planning is still a fairly new discipline," says Carl Telford, Futures Research Manager for Ricardo Strategic Consulting (RSC). "It's only in the last 20 or so years that it's been academically studied so it's not yet in enough companies' DNA. How do you justify spending money on something that might never happen?"

The pandemic has reinforced Telford's view that every organisation should be doing this type of long-term thinking – and not just because they're compelled to: "The advent of the Task Force on Climate Related Financial Decisions has brought transparency around the impact of climate change on business practice, starting with FTSE100 companies, so organisations are now effectively being forced to consider future scenarios. But scenario planning is broader than that.

"Why? Because it gives clarity to investors and could save money in the long run. The initial outlay will make a business's plans more robust whereas a shock to the system will cost far more. I remember talking to a retailer about long-range planning and they said they didn't need it. That was ten years ago – look at the issues facing that sector now."

A scenario, Telford explains, is not based around a single incident but multiple overlapping occurrences. In late 2019, Ricardo's scenario planning covered acute and chronic political, economic, health and environmental crises – including a health emergency in the mid-2020s.

And then COVID-19 happened.

"Scenarios don't predict, they prepare," Telford adds. "They are based on early signals of change. In a late-2000s project for an Original Equipment Manufacturer (OEM), one scenario included reverse globalisation and the partial break-up of the European Union. A decade before Brexit, the warning signs were there.

"Significant consolidation of the automotive industry is another prescient trend described in scenarios I've worked on. Companies have to embrace such uncertainties, not hide from them."

In RSC's award-winning white paper, 'Embracing uncertainty: COVID-19 and beyond', Telford, Charlie Allen and Jacob Foyle reviewed the findings of Ricardo's 2019 exercise to assess whether the scenarios were still valid and could offer clues about the post-pandemic world.

Telford is surprised only by the time taken to emerge from the maelstrom: "It's a bit like a cartoon fight where you see a cloud of smoke and limbs. We still don't know what's going to materialise when the COVID-19 cloud disperses. However, what's certain is that scenario planning cannot stand still – scenarios need to be refreshed every two years or so."

Telford also believes that future scenario planning will become more extreme: "The way this pandemic has played out," he warns, "shows that no scenario is impossible."

'Embracing uncertainty: COVID-19 and beyond': available at *rsc.ricardo.com/insights/embracing-uncertainty-covid-19-and-beyond*

02 DIGITALLY ENABLED PRODUCTIVITY GAINS WILL ACCELERATE INDUSTRY 4.0

If Industry 4.0 was relevant before the COVID-19 emergency, it's critical to how businesses recover from it, says Jeff Nichols, Vice President of Ricardo Strategic Consulting North America and disruptive technology expert.

RQ: Why did it take a pandemic to move some businesses beyond a technology tipping point?

JN: The pandemic drove transformational changes in numerous business operational practices and required deeper collaboration with internal and external suppliers. This has fuelled efficiency through flexibility as well as relying on digital twin engineering, testing and manufacturing operations.

One example of a recent engagement was learning of an operational management meeting that took place every Monday at 8am to walk through the operations, review quality metrics, throughput and scheduling. Today these discussions are taking place remotely and by leveraging remote guided video cameras and monitoring operational data metrics remotely. These are taking place 24/7 and can be tracked and monitored in real time and accessed in all time zones. This was a cultural shift that provided improved efficiency and reduced reaction times which equated to improved quality and reduced costs.

If you had said to me two years ago that I would see this change in companies that are high yield-driven, with rigid operating structures, I would have smiled. However, the pandemic has encouraged some businesses to think beyond what they thought possible. Manufacturing still goes on, what has changed is the technology-driven data that Industry 4.0 offers and harvesting the efficiency improvements that can be realised.

RQ: Has the pandemic brought an acceleration in how digital technologies are perceived: as productivity drivers rather than just sources of cost efficiency?

JN: From an efficiency standpoint, digitalisation was coming anyway. Likewise the digital twin in testing, calibration and validation. The pandemic hasn't driven these tools but necessity has pushed us to leverage them sooner.

In automotive, we can monitor material being developed before it's cast, then the machinability of the casting, then a digital tag follows the product all the way through the assembly process and into vehicle warranty data. There is now greater recognition of the productivity potential in harvesting that data and understanding its implications downstream, right through secondary post-processing and vehicle integration and performance.

03 DIGITAL RESILIENCE IS ABOUT MORE THAN JUST CYBER SECURITY

With technology embedded across almost every aspect of critical infrastructure, true digital resilience is not just about protecting IT systems against a cyber-attack. It's also about managing the interfaces between information networks and physical assets; identifying vulnerabilities in supply chains; and safeguarding interactions between staff and external environments.

According to Alzbeta Helienek, Principal Consultant for Ricardo Rail, the principles of digital resilience found in the rail industry are applicable in almost other sector: "It doesn't matter what the event trigger is, a fully-worked out digital resilience strategy will answer the key opening questions of any response plan: which assets are most important to you? How will you communicate with customers and staff? How will you facilitate quick decision making?"

The EU's Directive on the Security of Network and Information Systems is mandatory for rail operations but the approaches to business continuity and contingency planning that it advocates are a benchmark for the entire sector and its supply chain. The Directive sets out four objectives:

- Managing security risk;
- Defending against cyber attack;
- Detecting cyber security events; and
- Minimising the impact of cyber incidents.

"The Directive requires organisations to prioritise their most vulnerable and critical assets," explains Alzbeta. "They are expected to ask the 'What happens?' question then test their planned response. When responding to COVID-19, organisations which had gone through the digital resilience process were better able to make decisions at speed, apply disaster recovery scenarios and remain operational."

04 PRODUCT DEVELOPMENT NEED NOT BE CONSTRAINED BY PHYSICAL LOCATION

"Ricardo's 'digital first' strategy means we have been able to deliver services and products to our global customer base safely but remotely throughout the pandemic. We have relied on computer-aided design (CAD) and some of our 3D computational fluid dynamics areas on relatively high-powered machines for manipulating geometry, be that that in the CAD world or in some of the analysis. We're still solving in clusters at our Shoreham Technical Centre or at our technical centres in Leamington, Cambridge and Prague, but with multiple global sites, we were already familiar with online collaboration and meetings.

"We are looking at a transition from desktop-based activity, where an individual engineer has his task on his desktop, through to the collaborative environment. In effect, how to transition from desktop to server-based or Cloud-based methodologies.

"Adopting purely virtual methodologies means you're not constrained by needing to be attached to a physical piece of equipment. Traditional service providers in the industry undertake calibration using a physical asset test bed. There may be ways now of connecting to it remotely, but it's a physical 'thing' that has to be located somewhere and which requires someone physically present for manual operations.

"If we can transition into more Cloud-based methodologies of appropriate fidelity, then that's completely unconstrained by where people are physically. In addition, you can add elements of automation where things are just running in servers where you check in some new change to a model, or to calibration, and it goes off and runs the test suite of conditions to verify that the change is acceptable."

James Mullineux is Ricardo's Head of Digital Engineering

05 DIGITAL ENGINEERING CAN SPEED UP DECISION MAKING

"The pandemic," says Adrian Greaney, Ricardo's Director of Technology and Digital, "has been a catalyst in terms of information sharing and decision making. It has pushed us to use some of the agility and problem-solving skills that we apply to product development with our clients, in order to enhance the way we use digital data and models to collaborate more effectively."

Previously, explains James Mullineux, Ricardo's Head of Digital Engineering, simulation, software development, design, calibration and validation tended to be carried out sequentially: "The lines between these areas of engineering are blurring, enabling a far more rapid cycling of iterations before moving onto full validation analysis. Moving away from linear ways of working brings time and cost efficiencies."

These changes have been steadily taking place in industry but COVID-19 has quickened the pace towards continuous integration. "Customer expectation is that pre-pandemic timelines will still be met," says Jon Oakey, Ricardo's Head of Design Capability. "One part of the challenge we have faced has been to enable our digital engineering tools remotely while the other part has been to develop tools to communicate more effectively."

"Change control is still critical throughout," cautions Greaney, "but digital representation enables engineers across functions to have better understanding of the impact of their particular task in achieving the overall solution, which can only speed up decision making."

06 COULD VIRTUAL VALIDATION BECOME THE NEW NORMAL?

Lockdown saw Ricardo deliver a 'world first' in virtual vehicle certification. An automaker client and certification body were able to observe tests via a secure, live three-way feed to the automation and data management systems of Ricardo's advanced test facilities.

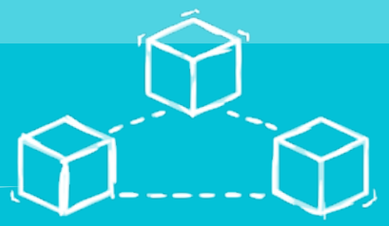
The first virtual certification tests were carried out in March 2020 and independently witnessed by a European agency. Further tests involved both complete vehicle certification and e-machine certification, executed remotely via Ricardo's UK technical centres at Shoreham, West Sussex, and Leamington Spa in the West Midlands.

Later last year, Ricardo extended this service to the marine sector. The company worked with Norwegian-based customer Bertel O. Steen Power Solutions to provide a virtual certification service for a large marine engine series.

Bertel O. Steen Power Solutions shipped the engine to Shoreham and the Ricardo team provided a suite of IT solutions to streamline the remote certification test process, including fixed and portable camera technology allowing inspection of the test-cell and emission measurement system checks. The customer, a Swedish sub-system supplier and the German-based independent witnessing agent were all able to monitor a process that would otherwise have faced major logistical challenges.

"The key deliverables of open, transparent testing, quality data, excellent digital security and a high level of responsiveness apply to any certification project," says Matt Beasley, Ricardo Director for Software, Control & Calibration. "We were able to apply our knowledge and experience of successfully performing remote/virtual test and certification events for e-machines, passenger cars, real driving emissions and other on-dyno testing to this particular marine project."

Will entirely virtual validation become the new normal? The various national lockdowns have given us a glimpse into what can be achieved with these technologies, in terms of keeping expensive and time-consuming physical validation to a minimum. However, while the circumstances of the pandemic have certainly accelerated progress towards a high proportion of virtual or digital, it's unlikely that we will ever completely do away with final physical validation and certification. *To find out more about Ricardo's efficient virtual calibration capabilities, watch our on-demand webinars: https://www.gotostage.com/channel/ricardo*



07 SUPPLY CHAIN REVIEWS CAN GUARD AGAINST FUTURE DISRUPTION

The disruptions caused by COVID-19 have had a traumatic impact on supply chain management. Organisations have been compelled to examine the inherent risks in their operations, as well as the practicalities of relaunching their chains and building greater resilience into operations, in a context of deep business uncertainty.

In the US, auto manufacturers sold more than 17 million vehicles for the fifth consecutive year in 2019 on the back of available credit, low unemployment rates and healthy consumer sentiment. "There was a sense that the bubble might burst," recalls Scott St. Clair, Vice President of Ricardo Strategic Consulting North America and a supply chain specialist, "but not from coronavirus. There was limited reinvesting in supplier capacity or capability, a focus on launch schedules and preparing for the next programme.

"Then the pandemic hit and most OEMs shut down, with a major knock-on effect to Tier 1s and below."

US car production fell from 2.62 million in February 2020 to 1.7 million just one month later and closed the year 15 per cent down on 2019. A pessimistic market in early 2020 saw the supply chain react by not planning for additional capacity. "When manufacturing reopened in China, cargo started coming in to US ports and the supply chain was not ready for it," St Clair says.

Recovery, he believes, requires a mix of tactical and strategic approaches. Short-term actions should focus on working closely with suppliers to identify those critical parts in the chain that will keep production moving. This needs to be allied to greater consideration for any business's key resource – its workforce: "The immediate challenge has been that of attendance and retention. Many people are still not comfortable going back to their workplace and that's caused major ripples into the supply chain. In fact, that's the number one concern for every OEM and Tier 1 I've spoken to over the last three months.

"What I hope we will see after the pandemic is a reset on employee relations that recognises workers' genuine concerns and goes beyond just the provision of PPE."

Other long-term considerations will help guard against future disruption:

- **Having a plan B:** Access to alternative suppliers will inspire greater confidence and help create a better-balanced supply base.
- **More visible supply chains:** A regularly updated supply base dashboard, including Tier 1 and Tier 2 suppliers, will allow quicker risk identification to support gaps in the chain as they arise.
- **Deeper risk analysis and monitoring:** Geopolitical, economic, global health and environmental risks should all be captured on a company's supplier risk management dashboard.
- **Product redesign:** Dependency on raw materials that are only available in specific regions is a clear risk. Product design may need to be reviewed to keep supply chains robust.
- **Prioritising digitalisation:** Automated tools deploying big data analytics can identify market sensitivities, perform real-time scenario analysis and inform allocation and replenishment strategies.

A Ricardo webinar, 'Reactivating the supply chain after COVID-19', is available to view at: rsc.ricardo.com/news/free-webinar-reactivating-the-supply-chain-after-covid-19

08 REMOTE WASTE AUDITING CAN MAINTAIN SUSTAINABLE OPERATIONS

Ricardo's waste experts found a way to keep performing the independent annual sustainability audits required by UK gas and electricity market regulator Ofgem for sites operating under the Non-Domestic Renewable Heat Incentive.

Companies were struggling to meet regulatory obligations with many customer sites temporarily closed or with limited access. The methodology, built around Ricardo's digital-first strategy, gave the necessary in-depth understanding of processes and procedures without the need for a site visit. The Ricardo team are deploying the same tools and principles to deliver technical due diligence for waste technology projects, keeping critical infrastructure work on track.

09 ENVIRONMENTAL IMPACTS UP FOR DISCUSSION BY OEMs

The first COVID-19 lockdown led to a 42 per cent decrease in surface-level nitrogen dioxide (NO2) pollution in the UK, according to a study recently accepted for publication in Atmospheric Chemistry & Physics.

"Some cities across the UK and mainland Europe are considering how they might be able to retain the air quality benefits resulting from reduced urban vehicle traffic during lockdowns," says James Mullineux, Ricardo's Head of Digital Engineering, "perhaps through a permanent reduction or even a ban on private transport in city centres. We have also seen a huge increase in online shopping and takeaway deliveries."

For OEMs, Mullineux believes these trends could bring about:

- An increased focus on light commercial vehicles over passenger cars;
- A greater focus on mobility solutions for centralised or city-based transport; and
- A review of propulsion strategy for private vehicles.

"These trends are forcing a discussion on the demands for different vehicle types and the right powertrain for the future," Mullineux adds. "The pandemic is the most extreme example of the uncertainty and complex challenges facing OEMs as they have to pursue relentless product efficiency while driving down harmful emissions, whether through de-fossilised fuels like hydrogen, increased electrification or other technologies which will reduce the environmental impact."

10 WE ARE LEARNING ABOUT OPPORTUNITIES TO IMPROVE AIR QUALITY

Ricardo is a member of the Business Clean Air Taskforce (B-CAT), a coalition of companies committed to improving air quality in the UK.

A B-CAT survey last year found significant public support for incorporating reductions in air pollution in business recovery strategies.

Furthermore, 85 per cent of those responding listed at least one specific pollution-reducing measure they wanted businesses to take, including more electric cars and vans for goods delivery and an increased number of click and collect grocery services.

"Not all air pollutant concentrations are directly related to transport, so we should not be complacent that tackling this sector alone is the complete solution," cautions Stuart Sneddon, Ricardo Energy & Environment Technical Director for Air Quality Monitoring and Modelling.

"However, looking forward, our approach to travel, remote working and selected modes of transport will be an important factor as we try to bring about sustained improvements in air quality."

A Ricardo webinar, 'Life after lockdown – exploring what lessons can be learnt from the impact of COVID-19 on air quality', can be downloaded at: ee.ricardo.com/downloads/air-quality

MAKING A MARQUE

BSA dominated global motorbike sales in the 1950s but failed to respond to emerging Japanese brands and by 1973 had sunk into oblivion. Now this iconic brand is looking to a future that includes electric bikes. **Ashish Singh Joshi**, Director – BSA Company Limited, tells *Ian Adcock* about his ambitious plans for one of the most famous names on two wheels.

OVERLEAF, A RICARDO PERSPECTIVE ON THE CHALLENGES AND OPPORTUNITIES FOR ELECTRIC MOTORCYCLES

The Birmingham Small Arms Company Limited, founded in 1861, was a vast industrial combine manufacturing bicycles to bolt-action hunting rifles; Daimler cars to iron castings; and machine tools to the BSA motorcycles that made it the largest bike producer in the world. First exhibited at the 1910 Olympia Show in London, the BSA 3½ hp machine on show caused a sensation and saw the entire production sell out for the next three years.

The group's post-war decline was a sorry tale of bad decisions and poor management amid fast evolving markets. A government-organised rescue bid in the 1970s led to a takeover of those operations still owned and a series of dispersals. The motorcycle brand went to Norton-Villiers – itself liquidated in 1978 – and then to a new BSA Company Limited.

Fast-forward to 2016, when India's industrial conglomerate Mahindra Group and its subsidiary Classic Legends acquired the rights to the brand in a £3.4 million deal. BSA Company Limited Director Ashish Singh Joshi picks up the story.

"THE BIKE HAS BEEN DESIGNED IN THE UK, ENGINEERED IN THE UK AND TESTED IN THE UK. IT'S A BRITISH BIKE AND HAS TO HAVE A BRITISH ETHOS"
ASHISH SINGH JOSHI, BSA

RQ: It is now five years since Mahindra acquired BSA. Why the delay?
Ashish Singh Joshi: The easiest thing to do is acquire a brand, the challenge is what to do with it. We have a good understanding of British motorcycles and BSA deserves an all-new product from scratch. That takes time.

I am proud to say that we will launch in 2021. The bike has been designed in the UK, engineered in the UK and tested in the UK. It's a British bike and has to have a British ethos.

Ricardo Motorcycle Group has worked on the vehicle engineering, the latest example of a partnership with Mahindra which dates back more than a decade.

You have ambitious plans for an e-bike?
Yes, we made the announcement last year after being awarded a £4.6 million grant by the Advanced Propulsion Centre towards developing an e-bike for launch in 2023.

This ties us into developing the motorcycle in the UK and then going forward to see if we want to manufacture it in the UK. As we move forward with its development further decisions will have to be made, but it makes sense to produce it in Britain.

The UK is known for cutting-edge technology that very few countries can match. We are working with Delta Motorsport on battery development, as well as the Warwick Manufacturing Group, while the e-motor comes from Dana which took over the British company, Ashwoods Electric Motors, late last year. The control systems and telematics are also all UK-sourced.

Battery costs are an issue at the moment but it is clear that price per kilowatt hour is reducing.

Ahead of this exciting development, what about plans for a conventional bike as well as new production facilities?
First we're going to establish a research and development centre in Banbury to develop the e-bike. We're also in talks to establish a manufacturing base in the West Midlands.

Pre-pandemic, we had carried out a number of site visits. Lockdowns around the world haven't helped but we should be able to make a decision about the location within the next six months and start moving people there – COVID-19 permitting, of course.

So what will the new BSA be like?
A lot of riders have started moving away from the 600cc to one-litre superbike category and are looking towards what you might describe as more 'sensible' bikes.

We think there's a place for a mid-range bike in character with BSA's past. It will be more road-friendly than a track machine and we'll start with the mid-weight.

BSAs were last sold in 1973. Two generations of motorcycle riders have grown up since then. How do you make a heritage brand relevant to potential new customers?
It is a challenge, I wouldn't say otherwise. The brand was so well loved and in its heyday in the late 1950s it was the largest motorcycle manufacturer.

If a product has credibility and looks beautiful then it will appeal to those who want a classic heritage product, irrespective of the market. In the long-term, BSA has the potential to become a global brand. RQ

NOT SO EASY RIDER?

Electrification is not a straightforward solution for motorbikes, as Paul Etheridge, Ricardo's Head of Strategy and Business Development, Motorcycles, and Principal Electrical Engineer Ben Evans, explain to Ian Adcock

"The e-bike market is quite immature," says Paul Etheridge, recalling that initial sales were city commuting e-bikes for short distances which, in his view, makes "a lot of sense".

Although the market rapidly expanded, particularly with sales of around 20 million in China, these e-scooters and e-bikes tended to be poorly engineered and manufactured.

"In the developed markets, the electric motorcycles which have come onto the market have generally been bigger machines with lots of torque to give an impressive riding experience. Unfortunately, these are relatively heavy, which compromises ride dynamics."

One concern, adds Etheridge, is cost: "A small e-bike can currently be up to twice the price of an equivalent petrol engine bike." The other issue is limited charging infrastructure which can prove to be "a real limitation. The big motorcycle Original Equipment Manufacturers (OEMs) are worried that with ownership models changing from buying to hiring on an as-and-when-needed basis, particularly for smaller commuter machines, there won't be a return on their investment into e-bikes."

Another challenge for the OEMs, according to Evans, is the touring market: "To do a typical 300-400-mile tour over a weekend on an internal combustion engine (ICE) bike is practically impossible on an e-bike due to lack of infrastructure and long recharging times."

What, then, is the motivation for the average Sunday rider to go electric? "You need to have a strong green ethic," says Evans, "or you're forced into it through legislation."

"The riding experience between future e-bikes and ICE bikes will be very different," Etheridge adds, "but we are talking to companies who want to develop big e-cruisers and performance superbikes that will have searing performance. These will be quite exotic to begin with, but heavy and expensive.

"However, things can change quite rapidly, and the COVID-19 pandemic could be a real game changer in our industry. We are seeing rapidly increasing demand for personal mobility and also many initiatives to help restart the economy with huge investments available to support a green transition. For these reasons, the motorcycle world will change significantly in the coming years."

STARTING FROM SCRATCH

Packaging is a challenge with e-bikes so OEMs would, according to Etheridge, need to "start from scratch" rather than try to modify an existing chassis to achieve an optimised design, with battery weight, size and position having a big influence on dynamics: "We can simulate dynamic behaviour of bikes at the CAD (Computer Aided Design) stage to help resolve these issues before we get into physical prototypes."

"On the plus side, says Evans, you don't get that typical vibration from the ICE when the bike is stopped at idle. This is due to the absence of a free spinning engine, as there's no need to keep revving the engine at standstill thanks to the e-motor being always ready to respond from zero revs, immediately giving the torque requested by the rider."

"Controlling that torque is all down to calibration," explains Etheridge, which is where riding modes become more important on an e-bike: "You could have numerous settings from very tame where, no matter how fiercely the twist grip is operated, there's a very benign, progressive acceleration to cruise conditions for touring, to all-out track-day modes. It's all down to software settings that would combine the e-motor's performance with suspension characteristics, traction control and other dynamic parameters."

Although some vehicle OEMs are suggesting multiple speeds for electric vehicle transmissions to maximise range, Evans doesn't see this as a requirement for e-bikes: "A single-speed is cheaper and easier to package, produce and ride as the e-motor is up to 95 per cent efficient for 70-80 per cent of its rev range."

"It's also about the riding experience," says Etheridge. "There are e-bike concepts with multi-speed gearboxes; you don't need it, but it could be considered fun changing up and down the 'box, and with an e-bike you could programme 'gear changes' into the software for an 'eco' or 'sport' mode to maximise efficiency or performance. In this case, the active synthetic noise will be essential to avoid the rider getting lost between the gears if there is little or no noise to communicate what the e-motor is doing."

Looking to the future, Etheridge sees that an intermediate-size e-bike would have particular advantages: "If BSA do as they're indicating, they will have a heritage product which would be a very popular alternative to ICE bikes.

"On a weekday the rider would set the 'eco' or 'commute' mode for maximum efficiency, especially in inner cities where ICE bikes are beginning to be restricted. However, on demand a different riding mode can be selected to get the best acceleration from the traffic lights, or for a more spirited weekend blast away from the city.

"The BSA brand lends itself to such a machine; initially it will be more expensive than its ICE twin but I can see a market emerging for early adopters who see themselves at the cutting edge of technology and the environment – someone who might buy the very latest iPhone, for instance. Given reasonable range and performance, this is a machine you could still go out and have fun on at the weekend."

The Ricardo Motorcycle team believe that the best e-bike is the one that provides the best overall balance between image, performance, weight, range and cost. "We are developing innovative new designs and appropriate new development processes to achieve this goal, with the expertise and synergies provided by our multi-national group of motorcycle-specific industrial designers, mechanical and electrical engineers, and professional test riders," concludes Etheridge.

NORTON ROARS BACK

BSA isn't the only British bike brand making a comeback, as Ian Adcock discovered when talking to Norton's acting CEO, John Russell

The parallels between TVS's purchase of Norton in April 2020 and Mahindra's acquisition of BSA go beyond the fact that another Indian conglomerate – TVS is India's third largest two-wheel producer, selling 4.95 million bikes a year – has bought an ailing British brand with the intention of resurrecting it.

"The previous owners did not have the financial capabilities to do the brand justice," reflects John Russell, adding: "Former Chief Executive Officer Stuart Garner had an eye for publicity and had raised Norton's profile so TVS joint-managing director, Sudarshan Venu, and I were confident that the company had potential. TVS bought all the assets and trademarks and took on the legacy of the 55 employees, then acquired the designs and the Ricardo input with engine development for both the twin-cylinder and V4 engines."

REBUILDING A PREMIUM BRAND

The driving force is TVS's desire to grow in the global bike market beyond its traditional sectors in India, Asia, Africa and South America: "We want to rebuild Norton on its original foundations as a premium British bike brand following threads from the past, particularly road-racing which is part of the defining nature of Norton."

At just over 6,500 square metres, the refitted former distribution warehouse in Solihull, West Midlands, is just the beginning, predicts Russell. The aim is to assemble between 5,000 and 8,000 bikes annually, depending on what is outsourced: "We see this as a medium-term rather than a long-term facility," he adds, with future plans including a purpose-built, ground-up factory "at some point".

The aim is to rebuild Norton on its original foundations as a premium British bike brand

The company will target segments where Norton is "relevant", says Russell. "We will be leading edge, design driven, experimental, creative Norton rather than resting on our laurels, but very British in design and characteristics."

Once existing orders for the Commando and V4SS are met, a range of more mainstream 650cc bikes will be the first step in growing volume from next year onwards. "Simultaneously, we're looking at a lower price point bike off the V4SS, plus clean sheet designs." Russell is determined that Norton won't be formulaic and draws a comparison with how Porsche turned its sales around with the Cayenne SUV: "A modern version of the Dominator, then enduro, soft-roaders, touring bikes and, if we end up with our equivalent of a Porsche Macan, that's what makes it fascinating."

As for thoughts around electrification, Russell recognises that this is "a challenge for Norton as so much of the bike's character comes from the look, sound and feel of the internal combustion engine and how the power and torque is delivered through the throttle and seat. We have to work out how electrification works for Norton."

Global green agenda

ROUTES TO NET ZERO

As countries strive for sustainability, zero emissions and cleaner living, the stage is set for another global industrial revolution. But this time it's green, finds **John Challen**

Cleaner shipping

Relating to the topic of 'jet zero and green ships' in the government's 10-point plan, Ricardo has been working with the Environmental Defense Fund, which supports the International Maritime Organisation. It is researching and studying the use of green ammonia to create hydrogen, which can be generated portside and used in various shipping applications.

This is a net zero fuel because it is created using renewable energy and, if the product is created in the port area, it doesn't have to be shipped elsewhere – it can be stored on the ship. In some cases, the projects that Ricardo has already undertaken are at the feasibility study stage, with reports of an anticipated reduction in shipping emissions by 20-50 per cent if the process was deployed globally.

Ricardo is now starting to work on the use of green hydrogen and green ammonia in marine propulsion systems.

Net zero heroes

A wide range of companies have worked with Ricardo to set out pathways for them to reach net zero carbon emissions. Offsetting – in the form of, say, planting trees – might seem an appealing option for some but, in reality, it's not as easy as it sounds.

In the case of Water UK, Ricardo worked with Mott MacDonald to develop a new route map that will create pathways to help the industry reach its emissions reduction goals by 2030.

The project team looked at the individual water businesses around the UK and identified pathways that would maximise freedom to achieve net zero in a way that helps the specific region as well as the industry as a whole.

Approaches used include different technologies, water sanitation and changes to how buildings are heated. In the pathways, scenarios are plotted to see by how much the grid decarbonises and the impact on the overall net zero goal.

Similar projects have been undertaken by Ricardo for the likes of the Scotch Whisky Association *(see page 26)***, Sustainable Wines, NHS Trusts in Scotland and Ministry of Defence facilities.**

In November 2020 the UK Government set out a 10-point plan for its 'Green Industrial Revolution'. The goal of the ambitious initiative is for the country to (among other things) recover from COVID-19, support green jobs and set out a route to net zero.

The plan covers initiatives in a wide range of market sectors, including offshore wind, hydrogen, nuclear power, zero emissions vehicles and greener public transport. Also listed within the future blueprint are: greener ships and buildings; investment in carbon capture; protection of the natural environment and green finance and innovation.

As a diverse organisation operating in many of those industries, Ricardo welcomed the plan and its objectives. It is keen to expand its work with government and industry to help achieve the goals, with the overall aim of getting to net zero emissions.

"Countries around the world had signed up to achieving net zero before 2050 but the reality is that their plans did not go far enough to achieve their goals," says Mike Bell, Ricardo's Group Strategy and Transformation Director. "We have seen that things aren't happening fast enough and, with COVID-19 and the need to stimulate the economy, governments around the world are putting their bets on the green recovery as part of their plan. It's a case of new jobs in new areas, rather than propping up legacy industries."

One of the biggest areas of focus within Ricardo is decarbonisation – an initiative driven by factors such as EU regulations and the realisation that fossil fuels will not be a viable energy source for much longer. The UK has led the way in decarbonisation, not least in the electricity market, which has seen wind and solar taking an increasing share of the power mix.

When it comes to transport, there is the ongoing need to reduce the use of oil. "The UK's 10-point industrial plan has a big focus on transport and the greening of transport and, as part of the jigsaw, there is a need to kickstart green energy generation," says Bell.

"If we are to use hydrogen to power vehicles, we need the infrastructure in place – unlike gas and oil, it isn't an untapped resource. We need to create it." At the moment 99 per cent of all hydrogen is generated from natural gas or coal gasification, so it's currently not 'green'. "If you've got a truck to run on hydrogen it's great because it only emits water, but we've

Taking a global perspective

The UK government's 10-point plan is not an isolated example of strategic thinking on sustainability. The European Commission's European Green Deal, launched at the end of 2019, makes a headline commitment for the EU to be carbon neutral by 2050 – which will require overhaul of every major aspect of the European economy through a framework of regulation and legislation. It's an extremely ambitious and challenging agenda, criticised by some as little more than 'greenwashing', yet European Commission president, Ursula von der Leyen, believes it to be a strategy for growth "that gives back more than it takes away".

Elsewhere, China's 14th Five Year Plan, due to be announced in March, is likely to make climate change a central policy priority with aggressive plans for green and low-carbon development. The goals set out by President Xi Jinping at the United Nations General Assembly in September 2020 were for the country to reach peak carbon emissions by 2030 and become carbon neutral by 2060. Expect to see an emphasis on green finance, technological innovation and clean production together with an expansion of environmental protection industries.

Moving e-motors forwards

The move to electric vehicles requires major investment to develop the necessary components. In the case of electric motors, Ricardo is leading a consortium funded by Innovate UK that concentrates on the supply chain element.

The UK-ALUMOTOR consortium will leverage Ricardo's manufacturing expertise to deliver next generation sustainable electric motors and also look at the manufacture of power electronics equipment.

Post-Brexit, shorter supply chains are more important than ever and motors that power more than just transport are vital. They will be used in so many different applications.

Comprised of six partner companies, the consortium will develop and refine a design fit for manufacture in the UK, which meets the needs of requirements of stakeholders both in the UK and also beyond. Over the nine-month project, the partners will identify preferred manufacturing processes, suitable for volume production.

A geographically diverse supply chain will eliminate the need for scarce material resources associated with expensive machines and also disrupt established supply chain monopolies.

A class-leading e-motor will help the UK capture part of a market that is predicted to be worth £28.5 billion by 2025.

Digital developments

The drive for greater cost and operational efficiencies has never been stronger for vehicle manufacturers, especially when dealing with the effects of the pandemic. These factors have accelerated the need for digital engineering and data-driven products and services for Original Equipment Manufacturers. There is a need to reduce the time for product iterations through modelling, simulation and virtual calibration within the product development lifecycle and to optimise real-world performance.

Amey Consulting and Ricardo are working on a plan to combine engineering domain expertise with digital analytics and data science understanding. The overall goal is to develop and bring to market new digital and data products and services that support clean, efficient and integrated propulsion and energy solutions for global transport manufacturers.

The partnership helps to connect vehicle manufacturing to highway infrastructure design and maintenance through the use of digital analytics and data science. It also creates an opportunity to deliver benefits to road users and drive the decarbonisation agenda.

generated much more CO_2 creating the hydrogen," reasons Bell. Ricardo has made no secret of its desire to become a world leader in hydrogen – see 'The power of H_2' feature on pages 20-22.

One subject highlighted in the 10-point plan that Ricardo isn't directly involved in is nuclear power, but Bell is ruling nothing out. "From an environmental point of view, people – not surprisingly – view nuclear with suspicion because, while it doesn't create CO_2, it has many other long-term legacy effects," he says. "I try to be more pragmatic about it because although we can generate lots of energy from wind and increasing use of solar, they are limited by time and natural resources. When there's no sun or wind, you've got nothing to back it up." The nuclear plus hydrogen option is to run nuclear plant as base load and convert some power to hydrogen when demand is low, such as evenings and weekends.

Bell firmly believes Ricardo has a big part to play in the UK's green future. "We want to be seen to be helping governments and organisations decarbonise and help achieve net zero," he says. "That's achieved by supporting policy work, through the consulting side and onto engineering elements of the business. From a transportation perspective, the first main area we're looking at is the transition from the internal combustion engine to electrification. Then the focus will be on the move to full battery transport and also hydrogen in the more 'hard to decarbonise' applications."

As our global snapshot shows, Ricardo is involved in a wide range of projects that are helping industries, governments and organisations achieve their net zero carbon emission goals.

Looking ahead to COP26

The 2021 United Nations Climate Change Conference, known as COP26, is a key date in the green revolution calendar. Taking place in Glasgow in November, the event will see extensive discussion about carbon reduction solutions at local and international levels.

COP26 will also see the ratification of the Paris Agreement, when countries are resubmitting Nationally Determined Contributions (NDCs) for review. From the UK's perspective, the aim is to demonstrate itself as a leader on the world stage, following departure from the EU.

The company's expertise across relevant sectors also makes COP26 a landmark event for Ricardo. Look out for in-depth coverage in future issues of *RQ*.

"We want to be seen to be helping governments and organisations decarbonise and achieve net zero... by supporting policy work, through the consulting side and onto engineering elements of the business"
Mike Bell, Ricardo Group Strategy and Transformation Director

A greener future for rail

» Decarbonisation challenges

Freight trains present the greatest challenges for rail decarbonisation: they are long, heavy, need 'go anywhere' capability and are typically powered by the most polluting fuel, diesel.

Ricardo has completed a policy study for the Rail Safety and Standards Board to look at options, including the use of electric, battery, hydrogen or biofuels, to find a way forward. The chosen power source had to be practical, given the heavy loads – and it proved a difficult question to answer. It would also require major investment in rail electrification, or a ready-made supply of the fuel near the network – as seen with diesel.

One option being investigated is whether the railway could carry hydrogen (or ammonia) onboard, reducing the need for extensive electrification.

Ricardo is currently looking for partners in the project who would be interested in exploring potential solutions.

» Electricity sourcing

Another project using capability from across the Ricardo business is with Riding Sunbeams. Network Rail is the single biggest user of electricity in the UK and also has key targets for decarbonisation.

The collaboration with Riding Sunbeams is developing the technical and commercial solutions to connect medium-scale solar photovoltaic plants – and maybe wind plants – directly to the railway. Located one to two kilometres from the railway, future rail systems will have direct access to affordable zero carbon electricity.

Feasibility studies have led to a small system being trialled at Aldershot station. Following this successful demonstration, Riding Sunbeams won a grant to take forward the first full-scale project of a four-megawatt site near Cuckmere, East Sussex. Ricardo is providing technical support to connect this solar plant to the Eastbourne to London line.

» On-track charging

Decarbonisation of the railway will not be straightforward, hence Ricardo is looking at a wide range of approaches. There are a number of hurdles such as the weight of batteries as well as storage and recharging limitations.

A concept called 'discreet electrification' could help overcome some of these issues: this allows battery powered trains to charge on the move. A battery powered train has a pantograph that is extended to overhanging electric wires and makes a connection. These wires would be placed every 50 to 60 kilometres and be around five km long. As the train passes through, it will recharge, to enable it to continue its journey without adding time to recharge at stations.

One advantage of this initiative is the ability to choose the quickest and cheapest five km along the route – thereby avoiding tunnels and level crossings. It is also the least disruptive measure to the rail network and can avoid areas of outstanding beauty.

Hydrogen future

The power of H2

Ricardo has accelerated its vision to be a leader in hydrogen, defossilised fuels and electrified transport engineering by announcing an initial £2.5 million investment in a hydrogen test facility at its Shoreham Technical Centre.

Steve Dyke, Managing Director of Ricardo Automotive and Industrial EMEA Division, explains how the company's expertise in what has been dubbed 'the fuel of the future' will help create a global centre of excellence and extend Ricardo's expertise in building solutions to support zero-emission transport.

Supporting the decarbonisation of the global transport and energy sectors is a key part of Ricardo's mission. Late last year the company joined the UK Hydrogen Strategy Now campaign, a group of businesses that are looking to invest £3 billion into hydrogen projects.

The global hydrogen economy is reckoned to be worth $2.5 trillion by 2050 and could support 30 million jobs. Australia, Japan, South Korea, Canada and China have already developed strategies for growing their hydrogen economies and Germany joined this list last summer with its own €9 billion hydrogen plan. The European Commission is also creating an EU hydrogen strategy, which includes plans for multi-billion euro investments in hydrogen projects, and schemes to boost sales of hydrogen electric vehicles.

The initial investment we announced in January to build a hydrogen development and test facility at our Shoreham Technical Centre in West Sussex is, firstly, a pledge to the clients we are currently working with on hydrogen and fuel cell technology, as we seek to provide clean and efficient solutions which reduce carbon and noxious emissions across a wide range of sectors.

Secondly, by building our hydrogen fuel cell and propulsion capability, alongside other investment in new facilities and technology for clean vehicles across all transport sectors, we will be able to expand the range of services and solutions that we can offer to clients in future. More importantly, we will be able to offer our clients the data and evidence from our designs and technology to help them make the right choices and de-risk their future technology and energy vector decisions.

The new facility is part of a plan for us to facilitate and grow a globally recognised centre of excellence for hydrogen, defossilised fuels and electrified transport engineering in the south-east of the UK. It will be at the heart of a local hydrogen eco-system consisting of technology development, supply and use of hydrogen.

We want to bring together industrial partners – whether multi-nationals, SMEs or start-ups, local universities, utility companies, transport operators and policy makers and draw on their capabilities as part of a unique collaborative hub.

We are already seeing progress towards this ambition. Brighton & Hove Buses, which operates the UK's first geo-fenced zero emissions bus fleet, is aiming for a zero-carbon fleet by 2030 and is actively looking at potential hydrogen bus models and infrastructure plus electric buses.

Also, Shoreham Port has begun work on a partnership with H2evolution to create a green hydrogen hub. A planning application will be submitted for a 20 megawatt electrolysis plant. Shoreham Port and H2evolution are, along with Ricardo, members of Hydrogen Sussex, part of the Greater Brighton Economic Board, which facilitates and supports the hydrogen economy across the region. We are delighted to see hydrogen being promoted in the area and fully support its production so close to our own planned hydrogen development and test facilities at Shoreham Technical Centre.

The hydrogen produced at Shoreham will be fully certified as green as it will be produced from a combination of captive

The global hydrogen economy could be worth $2.5 trillion by 2050 and support 30 million jobs

New curated information services on hydrogen development

Two new services from RiCK™ – Ricardo's online knowledge system – are designed to help navigate the complexities and potential opportunities presented by hydrogen innovation:

- **'RiCK News Hydrogen' is a weekly email update service offering the very latest in cross-sector information relating to hydrogen adoption. Drawing on content aggregated from 80,000 trusted news and relevant industry sources, the content is expertly curated by Ricardo. Articles are grouped into categories including hydrogen production channels, sector applications such as marine and rail, and wider contexts such as policy and regulation initiatives and strategic innovation programmes. One newsletter each month highlights key news items pointing to significant technical and market developments or trends.**
- **'RiCK Hydrogen Technical Update' is a detailed monthly technical digest targeted at engineering teams. The update will help engineers in hydrogen-related research and development projects, and includes a summary of recently published technical literature from sources such as the IMechE, Science Direct, Springer and SAE as well as white papers and other open access sources. There's also a comprehensive list of forthcoming conferences and webinars related to hydrogen, with papers sorted by subject.**

To sign up or find out more, visit: ricardo.com/rick/hydrogen-research

"We want to bring together industrial partners, policy makers and the academic sector in a unique collaborative hub" Steve Dyke, Ricardo Automotive and Industrial EMEA Division

renewable energy sources available at the Port and green energy, with guaranteed certificates of renewable origin, from the Grid.

Together with the University of Brighton and the Greater South East Energy Hub we are researching future demand for hydrogen for transport and potential locations for refuelling stations – with a view to making a business case for their implementation together with hydrogen production. The plans fit within the Greater Brighton City Region's recently launched environmental pledges, GB10, which commit the region to a range of actions on water and energy efficiency.

Digital engineering, digital twins and the application of smart automotive data science specialisms, together with the insights derived, will ultimately enable the complexity and risk posed by technology decisions to be de-risked on the balance sheet through the whole product and platform lifecycle.

Holistic strategy

The announcement of our new facility came only days after Ricardo unveiled a collaboration with AFC Energy plc aimed at identifying new and innovative alternative fuel solutions. We have been providing advice to both industry and government on hydrogen strategies and technology development for more than 20 years, while AFC Energy is a leading provider of hydrogen power generation technologies. This is another element of a holistic strategy and the incremental investments, partnership and approach are all closely coupled.

Combining AFC Energy's alkaline fuel cell technology platform, 'H-Power', with the expertise of specialists from Ricardo Energy and Environment and our Automotive and Industrial EMEA Division, our partnership will focus on joint creation of hydrogen fuel cell products and services, concentrating initially on marine, rail and stationary power generation. Together, our work will help play a part in global efforts to decarbonise transport, energy and nationally critical infrastructure. We have already submitted proposals to energy network operators with a focus on addressing needs related to strategic grid resilience and zero emission alternative power.

We know that the UK has real potential to become a global leader in renewable and low-carbon hydrogen technology. We want the UK to be to the fore, creating the next generation of green engineering talent.

As a business we are already feeling the pull from customers keen to deploy our expertise in hydrogen technology to support their sustainable bounceback from the challenges of the global pandemic. We're eager to play our part to drive growth in those sectors such as low-carbon energy, transport and heavy industry which will be essential for our future economy and for the UK's aspiration to be net-zero by 2050.

This is an exciting moment in history – a window of opportunity to really make a difference. It's where our passion lies here in Ricardo and we will be leading the way in investing in, commissioning and delivering cleaner, shared and sustainable transport. RQ

↳ Ricardo has created a new Hydrogen for Transport content hub. Visit: ricardo.com/hydrogen

Ricardo putting UK's first hydrogen powered train to the test

Ricardo has helped HydroFLEX successfully complete a mainline test of the UK's first hydrogen powered train. The project, led by rolling stock owner Porterbrook in partnership with the Birmingham Centre for Railway Research and Education (BCRRE), is designed to show practical applications of hydrogen as the power source for a full-size passenger train. Ricardo contributed in the key areas of safety case development and certification.

Based on a Class 319 electric multiple unit, the HydroFLEX vehicle's fuel cell is powered by hydrogen stored in high pressure tanks with oxygen sourced from ambient air. The fuel cell converts the mixture and generates up to 100 kilowatts of electricity for traction while emissions consist solely of pure water as a by-product. Two lithium ion battery packs store the electrical energy which powers the train's existing traction systems.

HydroFLEX was developed by Porterbrook and BCRRE as a response to the UK government's challenge to remove diesel-only trains from the national network by 2040. Hydrogen offers significant potential as an energy vector to help decarbonise the railway network, substituting for diesel power systems and eliminating emissions at the point of use.

Image courtesy of Porterbrook

INDUSTRY VIEWS

Insight into innovation, sustainability and technology

The forecourt deploys 'sun-to-wheel' infrastructure with electricity generated from solar power canopies as well as off-site solar farms

World's first electric forecourt open for business

More than 100 GRIDSERVE facilities planned over next five years

Thirty-six electric vehicles can be charged simultaneously at the Braintree Electric Forecourt®, just off the A131 in Essex, using ultra-high-power chargers delivering up to 350 kilowatts of charging power from renewable sources. Developed by clean energy company GRIDSERVE, the forecourt is a step forward in the expansion of the UK's electric vehicle (EV) charging infrastructure.

Drivers can add 200 miles of range in 20 minutes, a duration likely to reduce as EV battery technologies mature. With an initial cost of 24p per kilowatt hour (kWh) of clean electricity, a typical charge from 20 per cent of capacity to 80 per cent costs less than £10 for an average-sized electric vehicle. Future plans include 500 kW charging capacity, a tiered pricing structure and options for buses, trucks and other commercial vehicles.

The Braintree forecourt is part of GRIDSERVE's wider 'sun-to-wheel' infrastructure: electricity is generated from solar power canopies above the chargers as well as from a network of hybrid solar farms. The forecourt is paired with the UK's first subsidy-free solar farm at Clay Hill, Bedfordshire, providing fully renewable energy via the National Grid. A six megawatt hour battery on site also helps to balance the local energy grid and shift energy to periods when it is more valuable. For example, on a windy winter night the battery can store enough energy to deliver 24,000 miles of EV driving the next day.

While vehicles are charging, drivers and passengers have a lounge to relax in offering free WiFi, high-end washrooms, a dedicated children's area, a wellbeing zone with exercise bikes that themselves generate electricity, retail outlets and business meeting pods.

GRIDSERVE has also launched the UK's first net-zero EV leasing business. Energy is included in monthly leasing payments, meaning drivers can charge at Electric Forecourts® without additional costs. This, says founder and CEO Toddington Harper, addresses a key barrier to mass adoption by allowing for a more accurate comparison of the cost of leasing a petrol or diesel vehicle plus fuel against an EV with fuel included.

The project has been supported by Innovate UK and the Office for Zero Emission Vehicles, as part of the UK government's vision for a rapid chargepoint infrastructure to support early adoption of EVs ahead of the 2030 ban on the sale of new petrol and diesel cars. GRIDSERVE plans to roll out 100 Electric Forecourts® in the next five years.

Europe driving growth in EV sales

Global sales of plug-in electric cars grew by around 21 per cent in 2020, with the market proving resilient against economic challenges resulting from the pandemic and a significant contraction in the overall number of car sales.

According to analysis by market researchers IDTechEx, this level of growth is being primarily driven by Europe, which is closing in on China as the world's largest electric car market. Europe saw 78 per cent more purchases in 2020 with British consumers alone buying more than 75,000 battery-electric cars in the year to October, double the previous year's figure, plus another 50,000 plug-in hybrids.

Speaking at the Financial Times 'Future of the Car' conference, Nissan's chief operating officer, Ashwani Gupta, explained the shift to electric vehicles (EVs) had been driven by customer demand and enabled by infrastructure and government support. In particular, he cited European emissions restrictions as spurring global EV development.

Worldwide sales of plug-in electric cars were valued at $55 billion in 2020, with a forecast rise to $502 billion in 2030 and $1.2 trillion by 2035. Analysts expect to see an acceleration in sales in the US as President Biden plans to revise the relaxed US emissions standards, a critical policy driver, and invest in public charging infrastructure.

⇨ **Workplace charging is a key to increasing EV uptake though barriers still exist, according to a report by Netherlands-based EVBox.**

The charging stations and management software manufacturer's annual mobility survey of 3,600 people across six countries – Netherlands, UK, Germany, France, Belgium and Norway – found workplace charging accounted for 40 per cent of top-ups but only enough charging places were available 29 per cent of the time. The study also revealed that around two out of five of those surveyed work for a company that already has a sustainable vision in place, with Netherlands leading the way.

Urban mobility set for take-off

General Motors is the latest auto business to announce a move into aerial mobility with an electric vertical take-off and landing (eVTOL) personal aircraft. GM used CES 2021, the annual global tech expo, to reveal an animation of a Cadillac-branded, four-rotor aircraft powered by a 90 kilowatt hour (kWh) battery capable of reaching speeds of up to 90 kilometres per hour (kph). Images suggest the craft will be a single-seater air shuttle designed for autonomous short urban journeys.

GM's first move in the urban transportation sector seems to be linked to the company's investment in its Ultium electric vehicle hardware program, together with broader developments in batteries, electric motors and Cloud-based services for electric cars and trucks.

⇨ Others seeking to capitalise on available airspace include California-based startup Archer Aviation, who have partnered with Fiat Chrysler Automobiles (FCA) to develop an eVTOL. The aircraft would be powered by a 187-kWh battery pack and fly at up to 150 kph over distances up to 96 kilometres. Images released hint at a six-propellor, V-tail design; FCA has already collaborated on cockpit design. The ambition is to start manufacturing in 2023.

IN BRIEF

'Green' number plates on the road

Drivers of newly registered and existing UK electric cars are now eligible to carry a green flash on their numberplate as part of the government's plans to achieve net zero emissions by 2050. The flash is similar to those already used for country flags and EU badges.

The scheme is part of the Department for Transport's 'Road to Zero' strategy, making it easier for cars to be identified as zero emission vehicles and helping incentivise people to own them. A similar scheme in Ontario, Canada, has reportedly led to an increase in purchases of electric cars. Drivers may also benefit from local initiatives such as cheaper parking or cost-free entry into zero-emission zones where the 'green' numberplate will be recognised as eligible.

Autonomous vehicles spearheading 'a driving revolution'

Forty per cent of UK car sales could have self-driving capabilities by 2035, according to UK transport minister Rachel Maclean. Speaking at CES 2021, the annual global tech expo, Maclean cited a new report from Connected Places Catapult, the British government innovation agency for the transport industry and autonomous vehicles, Element Energy and Cambridge Econometrics, which identified a potential total market value of £41.7 billion by 2035.

This level of growth has the potential to create up to 40,000 skilled jobs in connected and autonomous vehicle technology and, said the minister, places the UK "on the cusp of a driving revolution unlocking vast opportunities for the UK economy and jobs market as well as significantly improving the safety and efficiency of how we travel over the coming decades."

Last August the government launched a consultation on the use of an Automated Lane Keeping System that can take control of a vehicle at low speeds, keeping it in lane on motorways. A response to the consultation is set to be published this year.

Driving the Electric Revolution

A share of £20 million in funding is available through a new competition, Supply Chains for Net Zero, which aims to facilitate UK supply chains and manufacturing capability growth. Focusing on power electronics, machines and drives (PEMD), the competition will enable future improvements in productivity, capacity, quality or efficiency for sectors including energy, industrial and transport. It forms part of the Driving the Electric Revolution Challenge, launched in 2019 by the Department of Business, Energy and Industrial Strategy. Details at: ktn-uk.org/electronics/der-iscf-challenge.

Keeping the lights on

Audi shows how delayed charging can ease pressure on the local power grid

What happens to the street lights when several electric vehicles (EVs) are carrying out high-power charging on a residential road supplied by a local network transformer? Those sceptical of electric mobility might argue that pedestrians had better take a torch with them.

Audi collaborated with IT service provider GISA and other partners to simulate such an overload scenario in the local power grid, in order to discover whether grid-optimised charging can ease the pressure.

Targeted communication between EV and grid operator is the key. In practice this means delayed charging, taking into account a driver's time of departure and the actual load in the power grid. The EV uses downtime to charge fully and relieve the grid. This is made possible by new modules in the domestic grid that allow house, EV and power grid to speak the same language.

The central component is a smart meter gateway (SMGW) – a device already mandatory in Germany if a household's power consumption exceeds 6,000 kilowatt (kW) hours per year. The SMGW creates a secure data connection between the house and the grid operator via a certified IT backend. All necessary information and control signals are targeted to the home energy management system or directly to the charging system connection that Audi offers as an option.

This allows the charging capacity of the Audi e-tron or Audi e-tron Sportback (Audi uses the term 'e-tron' to refer to all cars that can cover longer distances solely on electric power) to be reduced as required – up to 11 kW as standard and by up to 22 kW on request.

Both models are equipped with the necessary intelligence and Audi intends to provide this same ability in all its future electric models.

The technical standards and communication protocols needed for grid-optimized charging are already in place. In the medium term, the new networking technology will allow the charging capacity, time and duration to be controlled for each car. Other benefits may emerge, too: a customer who can charge at work could accept limitations on charging at home, in return for a discount on their energy price.

A smart meter gateway creates a secure data connection between house and grid operator

Global coalition launched to accelerate green hydrogen

Fifty-fold increase in production targeted within six years

Major energy companies have signed up to a new UN 'Green Hydrogen Catapult' initiative to bring down the cost of hydrogen production. Green hydrogen energy leaders ACWA Power, CWP Renewables, Envision, Iberdrola, Ørsted, Snam and Yara will work together to press for the deployment of 25 gigawatts of renewables-based hydrogen production by 2026, halving the current cost of hydrogen and bringing it below $2 per kilogram. The project is part of the UN Race to Zero, which encourages companies to commit to environmental action outside governmental frameworks.

According to a study by the Hydrogen Council, a global CEO-led initiative of 92 leading energy, transport, industry and investment companies, a $2 price could represent a potential tipping point. It would make green hydrogen and its derivative fuels the energy source of choice in some of the world's most carbon intensive industries, including power generation, chemicals, steel making and shipping.

Ahead of COP26, the next UN Climate Change Conference to be held in Glasgow in November, "the world urgently needs to ramp up deployment of breakthrough solutions like green hydrogen," says Nigel Topping, COP26 High Level Champion for Global Climate Action. "The bold vision and leadership of businesses can propel green hydrogen along an exponential growth trajectory to support economic recovery and deep decarbonisation sooner than anticipated."

CHEERS!

RICARDO DRINKS A TOAST TO MORE SUSTAINABLE SCOTCH

Scotland's national poet Robert Burns declared that 'Freedom and whisky gang thegither!' George Bernard Shaw proclaimed the aromatic nectar to be nothing short of 'liquid sunshine'.

Now, Ricardo sustainability and energy experts are raising a glass to toast the launch of the Scotch whisky industry's sustainability strategy, having played a key role in its development by analysing data from more than 120 production sites across Scotland. As a result, the Scotch Whisky Association (SWA) has announced that the sector has committed to achieve net-zero emissions in its operations by 2040.

Last May, Ricardo published an initial report for the SWA entitled 'Scotch whisky pathway to net zero'. This, explains consultant and report author Raphael Sibille, looked at practical ways to achieve that aim: "Our engineering team and carbon management experts examined energy use and emissions at sites across Scotland. We asked ourselves the question: what technologies can close the gap to net zero?

"We modelled seven technology scenarios, consulting with the sector to validate our assessment of what might be possible. We looked at how sustained energy efficiency improvements with anaerobic digestion, biomass, hydrogen and high temperature heat pumps could be deployed across the industry."

"WHISKY HAS A STRONG IDENTITY WHICH IS ROOTED IN LANDSCAPE AND A PRISTINE ENVIRONMENT. BUT IN REALITY MALTING AND DISTILLING USE A LOT OF ENERGY DURING THE PROCESS"
RAPHAEL SIBILLE, RICARDO CONSULTANT

Decade of progress

The Scotch whisky industry had launched its first environmental strategy in 2009. The new strategy builds on progress made over the last 10 years when distillers have succeeded in cutting greenhouse gas emissions by more than a third.

Raphael continues: "When we think about whisky, we picture sweeping heather moorland and tumbling clear streams. It has a strong identity which is rooted in landscape and a pristine environment. But in reality malting and distilling use a lot of energy during the process. So we needed to look at ways to raise steam using zero carbon technology."

Commitments in the latest strategy include making all new product packaging reusable, recyclable or compostable and ensuring all producers stay within a responsible range of water use, both to be achieved by 2025. Ricardo is now supporting SWA members to achieve net zero in line with the sector's goals and the Scottish Government targets.

Last year's report also highlighted some of the challenges faced by the industry, including a need for policy certainty around implementation of new technologies such as hydrogen. In a separate development, HySpirits 2 is a feasibility study funded by the Department of Business, Energy and Industrial Strategy to assess the use of green hydrogen in the distilling process. The project, led by the European Marine Energy Centre, follows an initial study which explored use of a hydrogen-fuelled thermal fluid heating solution to decarbonise the distilling process at craft manufacturers The Orkney Distillery.

"The new Scotch Whisky sustainability strategy contains ambitious targets to take the industry to net zero emissions in our operations, ahead of both Scottish and UK Government targets," says Dagmar Droogsma, the SWA's Director of Industry. "This has only been achieved through the willingness of the whole industry to invest and collaborate. We have made significant positive progress against our original targets but we need to go further and faster."

Raphael added: "It was a privilege to play a part in preparing Scotch Whisky for a sustainable future. It was a fascinating project and has given me a new appreciation for the processes behind the drink. It also gave me the perfect excuse to open the drinks cabinet, purely for 'research purposes'.

"So, here's to a dram of zero carbon whisky."

Creating a world
fit for the future

RICARDO

Powering Electric Futures

Ricardo is working with customers to reduce environmental impact with clean and efficient propulsion solutions.

We create robust offerings through innovation, advanced systems and cutting-edge tools. Our world-class research and development team defines future technologies to ensure a safe, sustainable mobile world.

We're driving cost out of electrification for original equipment manufacturers. As pioneers of energy efficiency, emissions reduction, and electrification, our developments include thermal management, connected battery management, high power battery packs and ultra fast charging solutions, and digitalising the production of electric and hybrid electric vehicles.

We offer a true end-to-end service - from concept to design to validation and manufacture – creating clean, efficient propulsion systems for the future.

Find out how Ricardo can help your product development.
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