Ricardo Quarterly Review **Winter** 2021/22

RQ

A focus on the latest in innovation, sustainability and technology

RICARDO

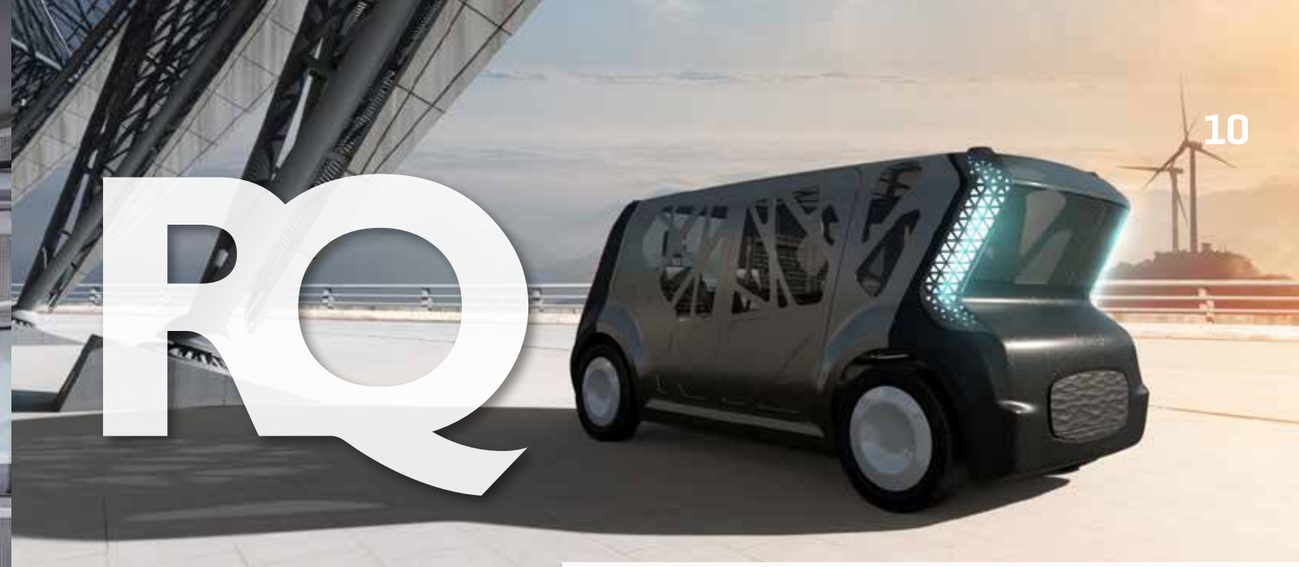
Call to MaaS
Sustainable materials meet Mobility-as-a-Service

Clearing the air
Tackling emissions in urban India

On the right track
Transforming Europe's rail infrastructure

CHARTING A COURSE TO A CLEANER FUTURE

Plotting the way forward for global shipping



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RQ NEWS

Latest developments from around the global Ricardo organisation

New air quality contract in Riyadh

Three-year project to provide world-class air monitoring data

Working in collaboration with air monitoring equipment supplier Envirozone LLC, Ricardo will be continuing to assure, audit and ratify data from a world-class monitoring network in Saudi Arabia's capital.

Initial projects, dating back to 2014, involved the supply, installation and maintenance of a 17-station monitoring network, along with ongoing quality assurance and quality control services for the network. Agreements for the latter have now been extended.

The monitoring stations each measure up to 15 pollutant species and generate more than 3.5 million hourly data points throughout the contract, all of which are validated using Ricardo's Modus data processing software. To ensure long-term benefits are delivered by the project, a parallel programme of knowledge transfer and training will be provided by Ricardo Environment Arabia LLC to the air quality team for the Royal Commission for Riyadh City.

Knowledge transfer and training will support the Riyadh monitoring programme

"This new contract cements Ricardo's business in Saudi Arabia," says Ricardo's Air Quality and Environment Practice Director, Sean Christiansen. "Our experts will be delivering a leading edge, sustainable solution in support of the city's ambitions for continued environmental improvement."

Funding to optimise climate control systems in electric vehicles

Innovation will help accelerate consumer adoption of battery EVs

Ricardo has received UK Government funding to improve in-car thermal and energy management systems to increase the range and battery performance of electric vehicles (EVs).

In partnership with Jaguar Land Rover and using a Jaguar I-PACE as a demonstrator vehicle, the company's engineers will examine whole vehicle thermal management. State-of the art digital modelling techniques will help to reduce energy consumption and boost driver and passenger comfort. The aim is to extend EV range by five per cent while cutting overall cost by ten per cent.

At the moment, the range of an EV is affected by hot and cold ambient temperatures. When drivers turn up the heat in their car in the winter or use air conditioning in the summer, electrical energy consumption rises. This can reduce the range of an EV by almost one-third.

The Ricardo team will apply advanced control approaches which automatically establish the best way to integrate new components and thermal system architectures into EVs, taking a system level approach. Engineers will also try to improve range by reducing energy consumption, product development time and costs through a predictive thermal management system using an electronic horizon. And an innovative 'comfort controller' will regulate heat sources to achieve a comfort level instead of a specified temperature.

Delving into biomass

The future of biomass supply and demand in Scotland is being researched by Ricardo experts. The team are working with ClimateXChange, Scotland's centre of expertise for climate change research and policy, to help progress the Scottish Government's Bioenergy Action Plan.

Specialists from Ricardo carried out a study for ClimateXChange in 2018 on the potential contribution of bioenergy to Scotland's energy systems, when availability of bioenergy feedstocks was previously projected for Scotland to 2030.

The new study will revise the previous estimates to 2045, evaluate bioenergy demand by various sectors, including industry, buildings, power generation, transport and agriculture, and compare bioenergy supply and demand in 2030 and 2045. Projections for Bioenergy Carbon Capture and Storage (BECCS) in the context of Scotland's world-leading 2045 net zero target are also a key focus of the project.

"As a negative emission technology, BECCS has an important role to help Scotland achieve its net zero targets," says Dr Naser Odeh, Associate Director and Head of Carbon Capture and Storage at Ricardo.

"Including BECCS in future pathways for Scotland has a significant impact on bioenergy supply and demand. We will be drawing on the pathways in the Committee on Climate Change Sixth Carbon Budget and the Scottish Climate Change Plan update as well as on recent literature, including Ricardo's recent report to the Department for Business, Energy and Industrial Strategy, 'Analysing the potential of bioenergy with carbon capture in the UK to 2050'."

Ricardo was selected for this project due to previous work for ClimateXChange on estimating biomass supply and expertise in biofuels, BECCS and other negative emission technologies.

Ricardo is helping to progress the Scottish Government's Bioenergy Action Plan

Technical oversight contract for new Metro route in Taiwan

Ricardo will be providing independent verification and validation services for phase two of the Wanda-Shulin line, a driverless metro route under construction in Taipei, Taiwan.

A key responsibility will be ensuring that this phase, a mostly elevated 11 km section due to open in 2028, will integrate seamlessly with phase one, a 9.5 km underground section due to begin passenger service in 2025.

The contract, worth £2.3 million, will include assessing whether the electrical and mechanical sub-systems – including rolling stock, infrastructure, communications and power supply – and their interfaces with civil and track works meet the required standards for functionality, quality and operational safety. The completed line will operate with driverless technology throughout.

The complexity of unifying two separate phases into a single route bears many similarities to the extension of the Blue Line in Bangkok, where Ricardo performed the same role during its conversion into a circular 'loop' line in 2018. The experience gained in Bangkok was a major factor in securing this work.

Ricardo's appointment continues a long relationship with the Taiwan rail sector. Previous work includes assessment services during construction of the original high-speed network between 2000 and 2007, as well as the Taipei-Taoyuan Airport rail link and Taoyuan City's Green Line.

Science-based emissions reduction target approved

Ricardo's proposed greenhouse gas emissions reduction targets have been approved by the Science Based Targets initative (SBTi). This means that emissions from Ricardo's operations (scopes 1 and 2) are consistent with the reductions required to limit global warming to 1.5oC.

SBTi is a collaboration between CDP (formerly the Carbon Disclosure Project), the United Nations Global Compact, World Resources Institute and the World Wide Fund for Nature.

The approved targets comprise commitments to:

- **Reduce scope 1 and 2 emissions by 46.2 per cent by 2031 from a 2020 base year, modelled using the Absolute Contraction approach;**
- **Increase annual sourcing of renewable electricity to 90 per cent by 2026; and**
- **Reduce scope 3 greenhouse gas emissions by 27.5 per cent by 2031 from a 2020 base year.**

"We are committed to integrating our climate change expertise into our corporate strategy," says Graham Ritchie, CEO of Ricardo plc. "We have set out ambitious greenhouse gas reduction targets, which include working closely with our supply chain to tackle our scope 3 emissions."

Trucking on

New projects to improve the performance and reduce the cost of heavy-duty vehicles

Manufacturers and fleet operators need novel technology advances to increase the take-up of electric trucks

Ricardo has won two UK Government-backed innovation competitions to make future electric trucks more efficient and support wider-scale adoption. Both will be developed in partnership with the University of Bath.

For the first project, funded by the Faraday Battery Challenge and supported by Innovate UK, Ricardo will examine the impact of integrating power electronics – a modular, series-connectable inverter and charger – into a battery pack with the aim of reducing the total cost of ownership. Efficiency improvements and a reduced powertrain mass could lead to savings of around £1,000 per vehicle and help to accelerate the adoption of electrified commercial vehicles.

The second project, which is funded by funded by the UK Department for Transport and delivered by Innovate UK, will see Ricardo developing technologies for future higher voltage (1400V) electric trucks to enable greater efficiency and faster charging. These technologies include a modular battery pack, advanced power electronics and an electrified drive unit optimised for high voltage use. This work builds on Ricardo's previous Future Truck research.

There are just over half a million trucks currently on the road in the UK but only 0.2 per cent of these are using cleaner propulsion. Vans and trucks make up 13.1 per cent of all vehicles yet account for around 35 per cent of CO_2 road transport emissions. With the UK Government proposing to end the sale of all new non-zero emission heavy goods vehicles by 2040, manufacturers and fleet operators need novel technology advances to increase the take-up of electric trucks while reducing cost, risk and time to market.

"Heavy duty vehicle CO_2 regulations will require manufacturers to reduce their fleet average CO_2 emissions significantly," says Teri Hawksworth, President of Ricardo Automotive & Industrial EMEA Division. "At Ricardo we are committed to supporting manufacturers and fleet operators by driving cost out of electrification and leveraging our expertise in battery, electronics and motor innovation."

Decarbonising iron ore pellet exports

Ricardo shows its mettle in emissions reduction planning

Ferrexpo, one of the world's largest exporters of iron ore pellets to the global steel industry for use as the raw material in manufacturing, is committed to achieving net-zero carbon emissions by 2050. Ricardo is helping to improve Ferrexpo's existing climate change scenario reporting and reviewing the role of the company's iron ore pellets within the circular economy.

"Through this collaboration," says Jim North, Ferrexpo's Interim Group Chief Executive Officer, "we expect to advance our targets and develop a clear roadmap for reducing Scope 1, 2 and 3 emissions. We also aim to identify market and regulatory risks and opportunities, model climate change scenarios and look at the environmental footprint of a Ferrexpo pellet beyond the steelmaking process."

In the 18 months to June 2021, Ferrexpo had already recorded a carbon reduction of more than 20 per cent. Through working with Ricardo, the company is aiming for a clear, science-based understanding of the carbon journey that lies ahead.

The results of Ricardo's analysis are expected to enhance Ferrexpo's carbon reduction targets and further develop climate change reporting in 2022.

Powering forward Formula E collaboration set to continue

Ricardo Performance Products is extending its successful relationship with DS Performance to design and supply transmissions for the team's car competing in the world's premier all-electric street racing championship.

The arrangement covers season 8 of the ABB FIA Formula E World Championship, which features 16 races between January and August 2022, and extends into seasons 9 and 10. It continues an alliance that resulted in the 'double double' drivers' and team championships for DS Techeetah in the 2018-19 and 2019-20 seasons.

Formula E is a competitive platform for global car manufacturers and mobility providers to test and develop road-relevant technologies. The series acts as a catalyst to help refine the design of electric vehicles and improve the driving experience for everyday road car users.

With typical 0-100 km/h acceleration of 2.8 seconds and incredibly high motor speeds, gearbox efficiency, weight and durability are crucially important. Ricardo's cutting-edge design and analysis methods, testing facilities and world-class advanced manufacturing technology will deliver transmissions to the required ultra-high quality standard.

The transmissions will be designed in conjunction with the team in Satory, France, and manufactured by the specialist engineers and niche manufacturing team at Ricardo's Midlands Technical Centre in Leamington Spa.

"Formula E demands excellence in driveline performance," says Martin Starkey, Managing Director of Ricardo Performance Products. "We have a long and trusted history with DS Performance and we are proud to extend our relationship into season 8 of Formula E and beyond."

VIEW FROM AVIATION

Why hydrogen-powered aircraft are the future of sustainable aviation

Jenny Kavanagh, Chief Strategy Officer, Cranfield Aerospace Solutions

Cranfield Aerospace Solutions (CAeS) are leading a consortium of companies, including Ricardo, to develop a hydrogen fuel cell propulsion system for the nine-seat Britten-Norman Islander aircraft. CAeS are also working with airports and operators to understand the implications of using hydrogen as an aviation fuel in a regulated airport.

Revolutionary change in the aerospace industry rarely happens in isolation. An external pressure is almost always involved. Development of the jet engine, for example, was advanced by the push for military advantage during World War Two.

Now, innovation in aviation is being propelled forward by a very different type of conflict – the war against climate change. Added thrust is coming from strategic goals, such as the UK's vision of net zero aviation by 2050. What's clear across every facet of the industry, from airframe design to materials to propulsion, is that this ambition must be also be commercially viable.

Hydrogen has become accepted as a viable fuel for heavy-duty road vehicles such as trucks and buses. So why not for aircraft? A technology base has developed over the last 20 years that the aerospace industry can make its own. At Cranfield Aerospace Solutions, we are capitalising on these advancements: our ambition, alongside the Original Equipment Manufacturer Britten-Norman, is to deliver the world's first passenger-carrying, regulatory certified aircraft powered by hydrogen. Named 'Project Fresson', we aim to have a hydrogen fuel cell-powered flying demonstrator in the air in the first quarter of 2023, with a commercial short-hop service operating in 2025. The only emissions will be water and heat.

> **HYDROGEN-POWERED PLANES OPERATING FROM SMALL LOCAL AIRPORTS COULD MAKE AIR TRAVEL AN EVERYDAY MOBILITY OPTION**

Design determined by technology

Within aviation, the opportunities and challenges for hydrogen are rooted in physics. Hydrogen has three times the energy of kerosene – which is good. But it takes up a lot more space – which presents challenges. For example, for a medium-range aircraft such as an ATR72, you would need a lot of hydrogen to enable a useful range. To house the storage tanks, you would need to remove a significant proportion of the seats, raising questions of the commercial viability of a retrofit (that's a lot of lost revenue). For this size of aircraft, it would be better to design from new so that the performance of the hydrogen propulsion system and aircraft in combination could be optimised; and that will happen - but it will take time.

In contrast, an aircraft such as the Islander, with only 9 seats and typically deployed over short ranges, needs so little hydrogen that it can be retrofitted with a hydrogen fuel cell system in a way that is still commercially viable and brought to market relatively quickly; this is important as it's the process of certifying these technologies where the real lessons are learned and where the real change starts to happen – a change that will enable the technology for the larger aircraft. Cranfield Aerospace Solutions have been designing and certifying complex modifications to aircraft for nearly 30 years. We know from experience that the hardest and most important lessons are learned in the certification process.

Doing this, however is more than just a technology step. Such a development may herald a change to the shape of sub-regional aviation. Fleets of hydrogen-powered planes operating from small local airports could make air travel an everyday mobility option. I believe that taking an electric taxi to "catch a ZEF (zero-emission flight)" will one day become as routine as driving to the station and catching a train.

What's more, digital communications and data-sharing will enable travellers to plan the cost and duration of their journeys in real time and also allow them to calculate – and minimise – their carbon footprint.

Ending aviation extravagance

At Cranfield Aerospace Solutions, we are not fuel cell evangelists. We work at the aircraft level and are simply interested in finding the sustainable technology that's best for the aircraft and its mission. From analysis and ongoing work we think hydrogen is the right answer – in what form will depend on the platform.

Yes, it will be some while before long-haul trips using hydrogen become a possibility. What may happen sooner is a reset to our concept of mobility, where a 12-hour direct flight is regarded as a damaging extravagance. Instead, the new convention could be a series of sustainable shorter hops facilitated through enhanced communications and digital interactions.

Human ingenuity and changing social norms will prove to be the ultimate drivers of this particular revolution. In the meantime, I confidently predict that by 2030, you will be able to fly to Paris for a weekend break on a guilt-free, zero-emission aircraft.

Visit projectfresson.uk for news and updates or follow on Twitter @projectfresson

THE BIG PICTURE

Bhubaneswar, India

Bhubaneswar, the state capital of Odisha on India's eastern coastal plains, is popularly known as 'temple city'. More than 500 historic structures still survive, honouring Lord Shiva, one of the most powerful gods in Hindu culture.

Home to more than 800,000 people and an important trading and commercial hub, the city also has one less appealing feature: some of the worst air in the world. According to the Air Quality Life Index, compiled by the Energy Policy Institute of the University of Chicago, Bhubaneswar is one of two cities in India where air pollution has reached levels described as 'alarming'.

The causes are wide-ranging, from straw burning after the harvest to poor waste management systems. What's certain is that streets clogged with traffic, and the dust pushed up into the air through vehicle movements, are key contributory factors. The state pollution control board has reported that levels of suspended particulate matter $PM_{2.5}$ and PM_{10} are well above acceptable levels even in the summer months.

Now, Bhubaneswar is set to benefit from a Low Emission Zone (LEZ), one of the first in India, following a capacity building project led by Ricardo. After publication of the concept report in September 2021, the scheme will focus on improving air quality in Ekamra Kshetra, the city's renowned temple area.

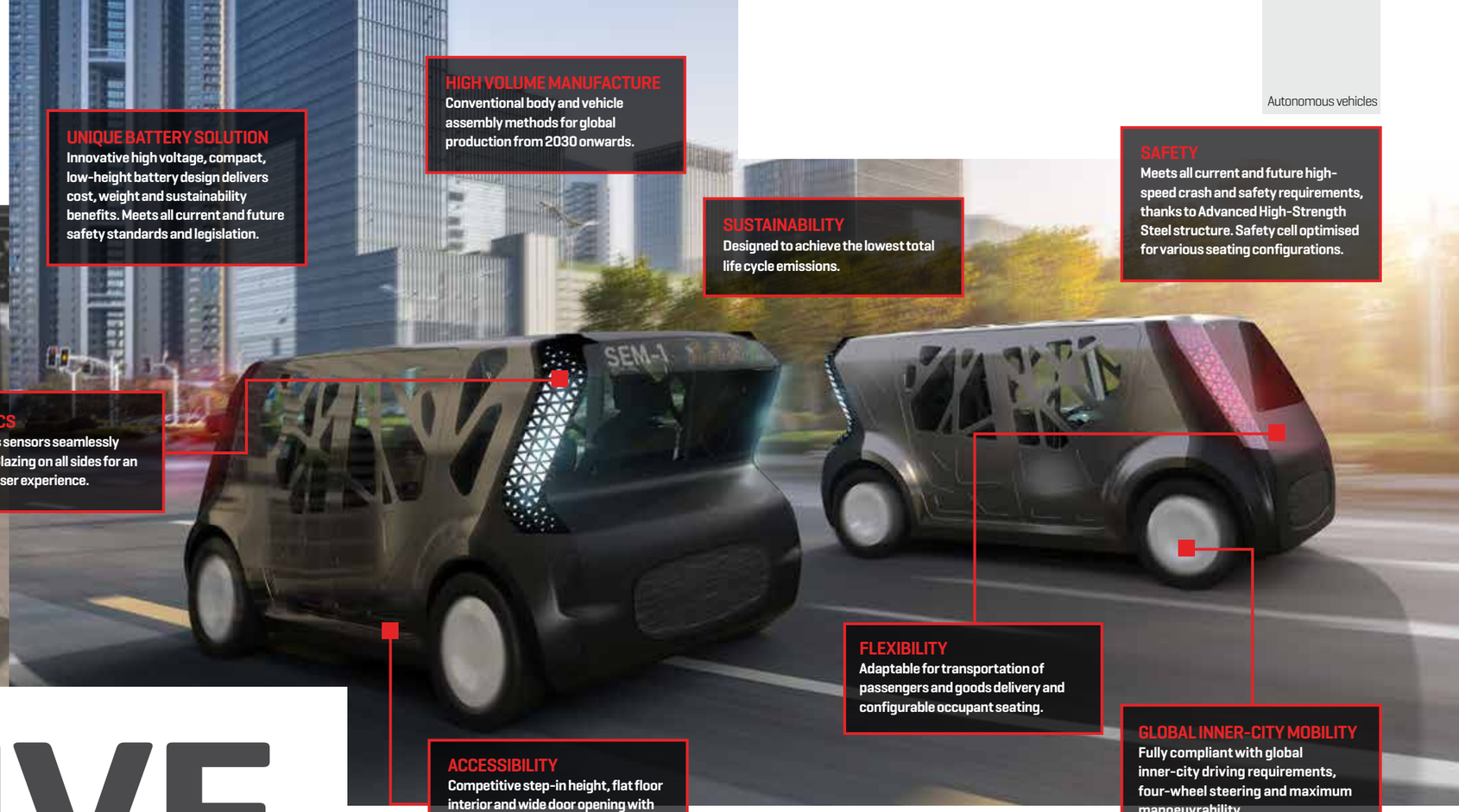
This initiative – and a similar LEZ in Leon, Mexico – is the result of a partnership between Ricardo's air quality team and Hevas Innovación, a Mexican consultancy. Funded by GIZ, a German development agency, the two came together to develop effective actions to reduce air quality impacts from transport across six cities in India and Mexico.

"The project has been delivered through a series of live events and webinars, including three 'Community of Practice' workshops," explains Charlotte Day, Ricardo's Project Technical Lead. "Participants from India, Mexico and Europe used a virtual learning space that gave access to a range of technical reports, articles, infographics and video presentations. Ricardo also arranged for expert speakers from Hamburg, Berlin and Oxford to take part.

"It's been a fantastic opportunity to engage with air quality professionals from around the world and support them with Ricardo's expertise in air quality action planning. The combination of technical material, along with peer-to-peer learning and sharing of experiences, has been incredibly effective at getting the best out of everyone involved."

As India grapples with its severe air pollution issues, the Bhubaneswar LEZ is another important step toward establishing vehicle access-restricted areas and moving such policy measures into the mainstream. Meanwhile, Ricardo's teams are working on another project in India for GIZ to help improve the Clean Air Action Plans for the cities of Surat, Pune and Nagpur.

Autonomous vehicles



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ACCESSIBILITY
Competitive step-in height, flat floor interior and wide door opening with reduced outswing to the roadside for improved access.

E-MOTIVE SUBJECT

Sustainable materials meet Mobility-as-a-Service in a joint autonomous vehicle project between WorldAutoSteel and Ricardo. **John Challen** explores this major development in next-generation transportation

Autonomous vehicles (AVs) have long been hailed as the biggest step forward the transportation industry is ever likely to see. A major element of this vision for the future is now becoming a reality through Steel E-Motive – a partnership between WorldAutoSteel and Ricardo.

Together, the two organisations are creating an AV platform that will spawn a range of transportation solutions. WorldAutoSteel comprises 20 of the largest automotive steel producers in the world and, for this project, Ricardo is the engineering partner.

Designs for SEM-1 and SEM-2 – the fully autonomous Mobility-as-a-Service (MaaS) vehicles at the heart of Steel E-Motive – have recently emerged. Specific details are being kept under wraps, but the intention is for them to provide a 'driving' range of 400-480 kilometres. That's enough to operate in a city for an entire day, without the need to recharge.

The vehicles are designed to offer technologies that will be deployable by 2030 and that meet the requirements of inner-city drivers. There's a four-seat version for urban use and another option with enough space for six passengers plus luggage intended for longer journeys. Such is the flexibility of the design, last-mile delivery solutions or standalone commercial vehicles are also potential future models.

The triggers for the project were increased industry activity around AVs and MaaS. "We saw a shift in the industry where vehicle production was moving from user-centric to MaaS," says George Coates, Technical Director for WorldAutoSteel.

"We thought the move to MaaS and AVs could potentially be the most significant development that we've observed in our careers and, as we weren't at the forefront of it, we really needed to understand it.

"That meant gaining insight into how it could impact material selection decisions for new vehicle architectures," he adds. "As you transition to MaaS and especially to Level 5 autonomous vehicles, vehicle architecture changes completely." Level 5 refers to the highest level of vehicle autonomy as defined by the Society of Automotive Engineers: vehicles that can pilot themselves in all driving environments at all times with no human input or oversight.

Focusing on the user

Fully aware of the challenges posed by steel and vehicle design, a vehicle development programme was established – and Ricardo entered the project, led by Neil McGregor, Chief Engineer, Systems Integration.

"We began work in July 2020 with a three-month feasibility study," he recalls. "It's a clean sheet vehicle, with quite different requirements and specifications to anything we'd done before. Therefore we spent time getting the primary layout of the vehicle right. Obviously with Level 5 autonomy you have no steering wheel, pedals or driver control. When you take those out of the engineering equation, it gives you a lot of freedom."

After those initial three months, the team worked to integrate the key components into the car, focusing on engineering, safety and – above all – the user. "We've engineered the vehicle to have a wide door opening to allow people to get in and out easily," explains McGregor. "It's got a flat floor, which means that disabled people and wheelchair user have very easy access.

"We've also put a lot of thought into how the vehicle is going to operate," he adds. The SEM-1 and SEM-2 have four-wheel steer, enabling better manoeuvrability around towns and cities. The models have also been engineered to meet all global high-speed crash requirements, which McGregor believes is an industry first.

"The characteristics of steel really

The vehicles at the heart of Steel E-Motive have a number of key design attributes

Striving for sustainability

The use of Advanced High-Strength Steel offers advantages from a design, safety and comfort point of view. There are, in addition, major benefits from a sustainability perspective.

"Steel has a small carbon footprint in terms of production of the material compared to aluminium and composites," says George Coates. "There are also major challenges around the recyclability of composites and plastics. Steel is not only recyclable, it's reusable: some of the components from Steel E-Motive could be redeployed in future vehicles if this proves scalable.

"Our reclamation and reuse factor is off the chart," adds Coates. "We're looking at about 95-97 per cent of the materials being reusable. Nor does steel recycling have to be closed loop: we can pull steel out of appliances or even cutlery and it can end up in a vehicle."

Call to MaaS

A number of factors have combined to move MaaS to the forefront of thinking within both the automotive industry and urban planning. The growth of megacities is one element but, more recently, the COVID-19 pandemic has inspired a fundamental rethink about how people move around towns and cities.

"In cities with mature public transportation, MaaS provides an alternative where someone might not be comfortable joining a vehicle with 20 or 30 other occupants," says George Coates. "With solutions such as ours, they can travel in a less congested atmosphere with just two to four passengers.

"There have been many hurdles in terms of technology and legislation around AVs but we're starting to see that changing. Cities and authorities are realising that AVs are feasible. We expect to see that trend continue in the coming years as MaaS solutions arrive. What we've heard from Uber and from DiDi – the Uber of China – is that their biggest cost element is the driver. Replacing the driver with an AV accentuates their business case."

help us in engineering," says McGregor. "The high strength and high ductility characteristics were essential to getting the end product. Over the course of the development, we've actually amassed a product portfolio of more than 60 different Advanced High-Strength Steel grades that are available.

"SEM-1 and SEM-2 have been developed to be battery-type agnostic. Furthermore, the pack-to-body battery structure eliminates a lot of the structural mass, leading to cost, weight and sustainability benefits.

"If you look at current electric vehicles, the battery pack is in an enclosure and then you bolt that into the vehicle," McGregor notes. "We've engineered a frame and the battery modules attach onto that frame. The frame is then put into the vehicle floor and covered at the bottom to eliminate the full structural casing. So we share the structure and the ceiling with the body structure."

Attracting future customers

With the design of the vehicles revealed, the 30-month Steel E-Motive project continues. The development team are helped by an advisory council featuring a number of established Original Equipment Manufacturers and start-ups who will hopefully become customers in the future.

"We identified mobility service providers as companies that would actually own these vehicles and sell the service, so it's vital to know what's important to them and what the total cost of ownership may be," says Coates. "Durability and longevity of the components are really important, as well as the attributes a provider could promote to a user of the vehicle. Therefore we need to make sure that the vehicle is safe and comfortable and has optimal user functionality."

Looking ahead to 2030, the likelihood is that AVs will travel along mixed-use roads, thus creating legislative hurdles to be overcome. "All the legislative bodies that we talked to said that they're not going to relax safety requirements or regulations for the introduction of these vehicles," says Coates.

"So right from the start, we decided that we needed to develop a vehicle that not only met today's crash regulations but also future ones. That's a big challenge when you're talking about a completely new architecture such as ours." RQ
https://steelemotive.world

"THE MOVE TO MOBILITY-AS-A-SERVICE AND AUTONOMOUS VEHICLES COULD POTENTIALLY BE THE MOST SIGNIFICANT DEVELOPMENT THAT WE'VE OBSERVED IN OUR CAREERS"
GEORGE COATES, TECHNICAL DIRECTOR, WORLDAUTOSTEEL

The pack-to-body battery structure eliminates a lot of the structural mass, leading to cost, weight and sustainability benefits

THIS MUCH I KNOW... STEVE BLEVINS

Head of Engineering, Ricardo Performance Products, on the ground-breaking Indy Autonomous Challenge

The Indy Autonomous Challenge is far more than just a motorsport event. Its purpose is to advance technology that can speed the commercialisation of fully autonomous vehicles (AVs) and the deployment of advanced driver-assistance systems. These will increase safety and performance in all modes of commercial transportation, not only motorsport.

The Challenge began in November 2019 and consisted of several rounds and hackathons in which teams from universities around the world demonstrated their ability to race a full-scale car autonomously. At the legendary Indianapolis Motor Speedway last October, teams had to develop software to enable a Dallara AV-21 car to drive autonomously in the uniquely challenging racetrack environment – with a first prize of $1 million on offer.

The Ricardo Performance Products team had a particular interest in the race. Building on our longstanding relationship with Dallara, our bespoke transmissions featured in all the competing cars. The transmissions were designed and manufactured by specialist engineers and the niche manufacturing team at the Ricardo Midlands Technical Centre in Leamington Spa.

Our engineering and manufacturing approach for this event was no different from the other race series that Ricardo supports. However, given all the cars are physically the same then ultimate performance was less important than driveability and reliability. Our focus was slightly different compared to series in which different chassis and gearboxes compete. The benefit of a 'spec' series is that no matter which team crosses the line first, our gearbox will be in the winning car!

The Ricardo transmission deployed in the Challenge was tried and tested. It has been used in the World Series by Renault and, currently, is used in Indy Lights

"NO MATTER WHICH TEAM CROSSES THE LINE FIRST, OUR GEARBOX WILL BE IN THE WINNING CAR!"

Presented by Cooper Tires, Super Formula in Japan, the Rodin FZED single-seat track car and the Japanese Inter Pro Series. The Dallara chassis for the Challenge is based on the IL15 chassis used in Indy Lights.

Removing the driver has a big effect on all aspects of the car. These include the gearbox which meant changes related to clutch control, gear ratios and gearshift. We were asked to configure the overall first gear ratio as low as possible to help protect the clutch on launch. The car uses a centrifugal clutch with the locking proportional to rotation speed: as the engine revs pick up, the clutch begins to lock and the car starts to move forward. During this process the clutch is slipping, so first gear ratio is as low as we're able to go to minimise this slip effect.

Nine teams took to the 2.5-mile Indianapolis track with four practice laps and two that were recorded. Speeds between 100 and 125 mph were expected but several went faster, notably TUM Autonomous Motorsport from the Technische Universität München who recorded a combined two-lap average of 135.944 mph.

The Indy Autonomous Challenge is making history again in 2022. The technology event CES is hosting an autonomous racecar passing competition at the Las Vegas Motor Speedway in January featuring several of the teams that competed in Indianapolis. RQ
indyautonomouschallenge.com

NDCent haste

"CLOSING THE GAP BETWEEN CLIMATE TARGETS AND CURRENT POLICIES WILL BE THE AIM FOR MANY OF THE COUNTRIES OUR RICARDO EXPERTS WORK WITH"

A key outcome of COP26 was a request for countries to revisit and strengthen their climate actions by the end of 2022. The focus this year, says **James Harries**, Ricardo's Principal Consultant in International Climate Change, must be on implementation as well as setting stiffer targets.

Many of the statements and declarations made at COP26 last October are now the subject of intense analysis, discussion and scrutiny: from the coal phasedown to long-term targets such as India's 2070 net zero pledge; from climate damage compensation for poor and vulnerable countries to an enhanced transparency framework for tracking progress.

Everything said in Glasgow was towards one aim: the ambition to keep global temperature rises to within 1.5°C above pre-industrial levels.

Under the 2015 Paris Agreement, signatory countries agreed to submit increasingly ambitious emissions reductions plans in their climate actions, known as Nationally Determined Contributions (NDCs), every five years. However, after initial enthusiasm about this agreement and the first round of updates, it became clear that the pledges were still not enough to deliver the 1.5°C goal.

That hasn't changed. And the urgency of the issue means we can't wait until 2025 to revise the NDCs again. What is being sold as the 'big win' from COP26 in terms of mitigation is Article 29 of the Glasgow Climate Pact, which 'requests' countries revisit and strengthen their NDCs by the end of 2022.

At Ricardo over the last eight years we've worked with policymakers from more than 20 countries to develop, implement, finance and update their NDCs, including specific action plans for sectors such as energy and transport.

As we move into this critical year for climate action, two things must happen. First, we need clarity on which NDCs need updating. Second, the focus needs to shift towards implementing policy as well as on the NDC targets.

Who should update their NDC?

Article 29 talks about countries revisiting and strengthening their NDCs 'as necessary to align with the Paris Agreement temperature goal'. The immediate question, then, is: which countries' NDCs are not currently aligned? Some didn't update their NDCs before COP26 so they should obviously be a priority. Indeed, that group of countries has its own paragraph in the Glasgow Climate Pact, urging them to produce updated NDCs as soon as possible and certainly before the next COP in Egypt in late 2022.

What about those that have already updated their NDCs? How do we know which countries need to update again?

The first thing to consider is how ambitious their NDCs currently are. For example, Ricardo helped Nigeria to update its NDC before COP26 and the Climate Action Tracker (an independent scientific analysis that tracks government climate action and measures it against the globally agreed aim of the Paris Agreement) has put it into the category of 'almost sufficient', along with only seven other countries (no countries' NDCs are deemed 'sufficient').

This means that Nigeria's NDC is compatible with warming of less than 2°C and could be made '1.5°C-aligned' with only moderate improvements. Attention needs to be on those NDCs that are deemed to be either 'insufficient', 'highly insufficient' or 'critically insufficient'.

Another factor is countries' influence on global warming. Currently more than 70 per cent of global emissions (and a much greater proportion of cumulative emissions) come from the G20 countries.

Putting the scale of emissions from a country and the strength of its current targets together, the focus over the next year should be on those large emitters that have either not yet updated their NDCs or whose update is deemed insufficient. We should be targeted and selective with further revisions because countries need to make progress with implementing their NDCs and the revision process makes this more challenging – but not impossible.

Why implementation matters now

The Climate Action Tracker's analysis of the commitments made in Glasgow makes for sobering reading. Much has been made of two numbers – 1.8°C and 2.4°C of warming.

The former is what we could achieve if we count not just the NDCs updated before COP26 but also the various long-term targets and other pledges made (such as cutting methane emissions and ending deforestation). The latter is what we'd get if the NDCs alone, as updated prior to COP26, were met in full.

Fewer people are talking about another number, 2.7°C of warming, which is what we'd get based on the current policies in place to tackle emissions. That figure is truly alarming. And the reality is that based on existing policies, current NDCs are not likely to be met.

Asking countries to update targets that they are currently not on track to meet is a big ask. That's why it's crucial that all countries work intensively on implementing their NDCs over the coming year. This means developing or updating NDC implementation plans, developing specific policies, attracting support for their implementation, putting in place governance structures and building capacity to allow all this to happen. Closing the gap between climate targets and current policies will be the aim for many of the countries our Ricardo experts work with.

As for those countries whose NDCs are not currently deemed to be aligned with the Paris Agreement's temperature goal, further work to raise ambition could be done alongside this implementation support – but not in place of it.

The Ricardo team left COP26 feeling both frustrated and excited. Frustrated that more progress wasn't made but excited that a clear signal was given for the need for more action. We've been centrally involved in the NDC process since 2014 and our company vision is to create a world fit for the future. Never has that call to action mattered more.

Find out more about Ricardo's world-leading climate change and sustainability support: ee.ricardo.com/climate-change

Zero-emission shipping

SETTING SAIL TOWARDS ZERO EMISSIONS

A revolution is underway in the shipping industry – and it needs to be complete in less than three decades. *RQ* examines the financial, logistical and technical challenges that must be overcome if thousands of zero-emission ships are to be off the drawing board and in the water by 2050.

International trade can't happen without shipping – this has been highlighted to politicians and the public alike during COVID 19-related supply chain shortages and the Ever Given running aground in the Suez Canal. More than three-quarters of total freight transport movements are by sea.

The downside to this vast scale of operation is that international shipping uses about 350 million tonnes of fuel each year and emits around 940 million tonnes of carbon dioxide, despite being the most efficient way to carry cargo in terms of energy use per tonne. That's 2.5 per cent of all greenhouse gas emissions globally – more than the sum of emissions from the whole of Germany. As other transport sectors take action to decarbonise, this percentage will only increase.

Today, just 0.1 per cent of energy consumed in shipping comes from low-carbon fuels, according to the International Energy Agency (IEA). Under the IEA's policy framework scenarios, low and zero-carbon fuels would still make up less than three per cent of shipping's total energy consumption by 2030 and just one-third by 2050.

The International Maritime Organization (IMO) – the UN body delivering international shipping's strategy on tackling climate change – currently has targets to cut emissions by at least 50 per cent by 2050 compared to 2008 levels and to achieve a 70 per cent carbon intensity improvement by 2050.

A recent report from the International Energy Agency[1] suggests that, at present, the sector will fall short of that figure. The report highlights the need for innovation to ensure zero-emission, ocean-going vessels are commercially available by the mid-2020s; for policies to reduce the carbon intensity of shipping activities, such as energy efficiency measures and slow-steaming requirements; and for investment in low- and zero-carbon fuels and technologies.

According to Graeme MacLean, Principal Consultant at Ricardo Energy & Environment and author of the white paper, 'Buoying up ambitions for decarbonisation'[2]: "The third of those points is particularly important given that fuel accounts for between 35 and 53 per

Zero-emission shipping

cent of the total operating cost for ships. This means the desire to reduce emissions has to be balanced against the cost-effectiveness of alternative fuel sources.

"Also, seagoing vessels have long lead times and lifetimes. If action isn't taken now, the sector not only risks locking in emissions for many years ahead, it also faces the prospect of vessel financiers demanding 'decarbonisation-ready' on new builds before the technologies are in place and factoring in the cost of zero-carbon retrofits when assessing the value of an existing fleet."

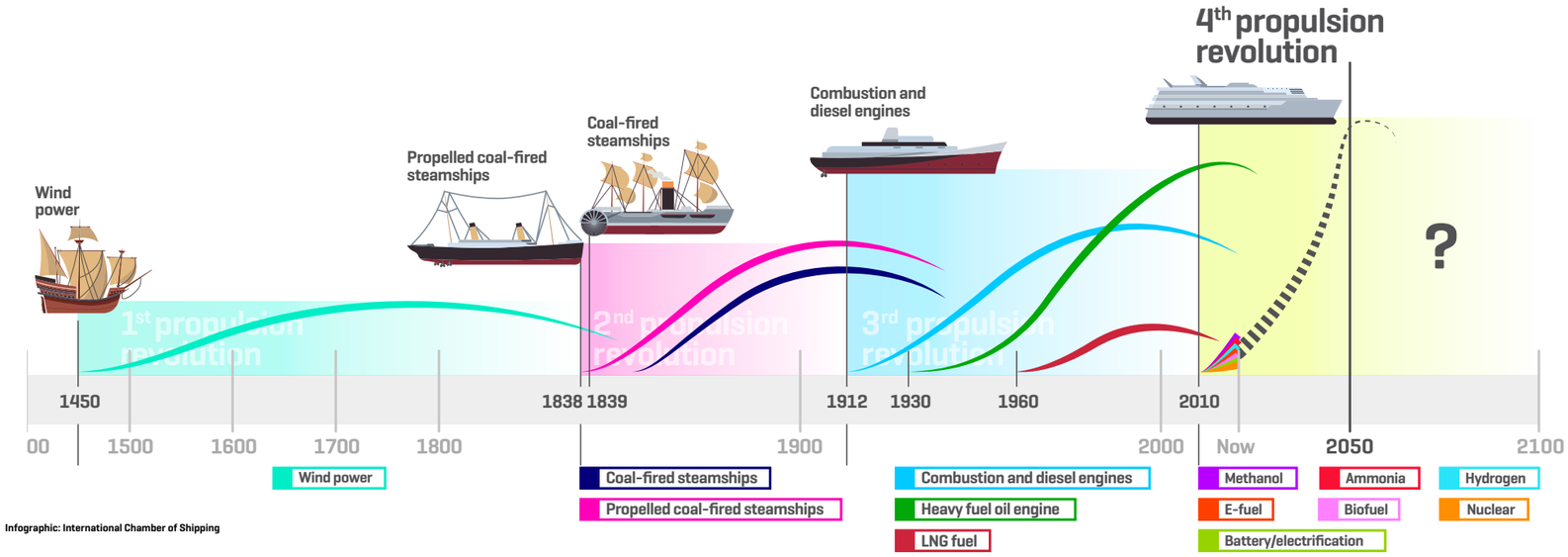
Addressing the drivers for change

Pressure on the sector comes from different quarters, not least the supply chain's desire for decarbonised goods. After all, if net zero products are to be exported around the world, into and out of ports with their own air quality and emissions targets, the ships themselves must also become clean and net zero. Among the key political drivers for change are:

- **Global:** the IMO targets mentioned above are likely to be tightened when a revised strategy is published in 2023. At COP26 the International Chamber of Shipping proposed net zero by 2050 to the IMO.
- **Regional:** In its July 2021 policy package, 'Fit For 55', the European Union (EU) included a proposal to extend its emissions trading system to include the maritime sector, as well as proposals for alternative fuel infrastructure, upper limits on the greenhouse gas content of fuels and EU-wide minimum rates of taxation on marine fuels.
- **National:** The UK is aiming for a net-zero maritime sector by 2050 at the latest, through measures including extending the Renewable Transport Fuel Obligation to support renewable fuels of non-biological origin used in shipping and consulting on a phase-out date for the sale of new non-zero emission domestic vessels. Elsewhere, the United States Government is pushing for total decarbonisation of shipping by the middle of the century.

Tackling uncertainties

Compared to shipping, motor manufacturers seeking to decarbonise have it relatively easy (even if it might not feel like it!). The zero-carbon transition for maritime vessels is much more challenging than the switch to electric road vehicles. For example, a large container ship travelling from China to Europe would need about one million Tesla batteries to complete the journey. This is one reason why EVs are an increasingly common sight on our roads while almost all ships still use fossil fuels.



Infographic: International Chamber of Shipping

A major barrier to change is that several future fuels could become viable for decarbonising shipping. From hydrogen, ammonia and methanol to biogas and synthetic fuels, the choice is wide. To add to this complexity, the current 'one size fits all' situation is unlikely as different fuels may suit different classes of vessel and operating patterns: international cargo ships with long trans-oceanic voyages, for example, may need a different solution from passenger vessels doing short Channel hops.

"These challenges and uncertainties affect the complex maritime value chain, from vessel charterers and operators to legislators, ports, bunkering suppliers and fuels manufacturers," adds MacLean. "Little wonder that many decision-makers are reluctant to invest in a specific technology for fear it could turn out to be an expensive wrong decision."

Shipping companies will also need to consider which ports offer the fuel type they choose, while the ports will have to look at their customer base and decide which fuels and refuelling capacity to invest in. Some of the potential fuels will not have the range to match existing energy-dense fossil fuels. For some types of vessels this could mean a trade-off between frequency of bunkering and cargo capacity. Decision-makers will need reliable information to understand the best options for their fleets or their fuel and port customers.

Overcoming challenges

The Ricardo white paper, 'Buoying up ambitions for decarbonisation', highlights five key challenges relating to technology and fuel:

1. **Distractions.** Fossil liquefied natural gas (LNG) is considered by some as a transition or interim fuel. However, this could divert investment away from truly sustainable zero-carbon options. And businesses are unlikely to pay to retrofit vessels and upgrade infrastructure twice – once to methane then a second time to a fuel such as ammonia.
2. **Cost-effectiveness.** The dominance of shipping as a means to transport people and goods is dependent on the cost of fuel. Future fuels will be more expensive, but by how much? Estimates vary as many of the underlying technologies are only beginning to scale up. This adds to the difficulty of planning investments in vessels and infrastructure.
3. **Reliability.** Marine powertrains and associated onboard systems provide many years of dependable service. Will powertrain manufacturers be able to provide assurance over the long-term reliability of new propulsion solutions running on different fuels?
4. **Availability.** Large methanol engines are already available and large ammonia engines are coming to market soon. However, marine megawatt-scale fuel cells are not readily accessible. Some shipyards are starting to build vessels that will be set up for zero-carbon fuels but the choice and scale needed for a full transition to cleaner fuels doesn't exist yet.
5. **Avoiding speculation.** To meet the decarbonisation targets set by the IMO, operators could choose to use other emerging technologies, such as onboard carbon capture, wind or hybridisation, rather than cleaner fuels.

The urgent need for climate action is hastening the fourth propulsion revolution

Will these technologies or the new fuels deliver a better return on investment? Could they be used in combination to offset increased fuel costs? And will regulators move the goalposts on the pace of decarbonisation? Decisions need to be based on evidence rather than speculation.

Taking action now

Given the urgent need for climate action stated unequivocally at COP26, delaying until the perfect, low-cost, low-impact technology is available is no longer an option – in particular for high-visibility industries such as aviation and shipping. This is the rationale behind policies with international reach such as the EU's 'Fit For 55' package, which aims to reduce CO_2 levels by 55 per cent by 2030. These policies will impact shipping, with financial penalties for those who fail to act.

While progress is being made, with revisions to the IMO decarbonisation strategy in 2023 expected to set tougher targets, and progress has already begun with Lloyds Register approving in principle five ammonia-fuelled ships within the last three years, "the sector risks finding itself in a Catch-22 situation," says MacLean. "Vessel owners can't risk ordering a ship which may have nowhere to refuel while the marine fuels sector can't build fuel infrastructure for which there may be no demand.

"It is forecast that the majority of investment will be required for fuel production and bunkering infrastructure," MacLean adds. "But until commitments are made to go down a particular route, few are willing to take the risk. Governments may be able to help by providing funding for

RESEARCH AND DEVELOPMENT IS KEY FOR SHIPPING TO REACH NET ZERO

At COP26, with my colleague Alex Devlin I helped to present the findings of Ricardo's report, 'A Zero Emission Blueprint for Shipping'[1], which we developed for the International Chamber of Shipping (ICS). The report sets out the research and development projects needed to address the challenges to decarbonising shipping.

The ICS has proposed a net zero target for 2050, which is an advance on the International Maritime Organization's current target of a 50 per cent reduction. This more ambitious target is in line with the ambition of COP26 and responds to the net zero targets of many shipping customers, who know that the bulk of their emissions footprint is in their supply chain (which includes shipping).

Vessels have a lifespan of 20–25 years or more so the first commercial zero-carbon ships must start to be deployed in the next decade if the industry is to meet these targets.

More than 60 per cent of the emissions reductions required in 2050 will come from technologies that are not commercially available today. It is therefore vital that the pace of research and development (R&D) into maritime fuels and technologies accelerates – and that the finance is in place to enable this to happen. However, the latest figures on private sector maritime R&D produced by the International Energy Agency show that spending has actually fallen – from $2.7 billion in 2017 to $1.6 billion in 2019.

In the report, we identify 265 projects that address the key technical and systemic challenges that need to be overcome if we are to accelerate the transition to zero-carbon emissions. We present 20 projects in hydrogen, ammonia and battery power in greater detail as they serve as a potential blueprint for R&D projects to be commissioned in the near future and give the broadest coverage of zero-carbon fuel and technology options available to the sector. Many will take between one and six years to reach commercialisation. The estimated cost to fund these projects? $4.4 billion.

The concept of a $5 billion IMO Maritime Research Fund (IMRF) has been developed over the past four years, with the full backing of the global shipping industry and a number of governments. The fund, established by the UN International Maritime Organization, would be raised from 2023 via mandatory R&D contributions from shipping companies. It is urgently needed if we are to advance the alternative technologies and fuels needed at the required pace and scale.

[1] ics-shipping.org/publication/a-zero-emission-blueprint-for-shipping

Colin McNaught is Director, Strategic Growth & Development, at Ricardo Energy & Environment

Zero-emission shipping

infrastructure as proof of concept; but for larger scale adoption, it will fall to industry to make the leap, perhaps with some government incentives.

"One possibility could be agreements between vessel operators and the specific ports they operate from for a long-term clean fuel purchase agreement – which aligns with the Clydebank Declaration for green shipping corridors made at COP26 to support the creation of zero emission routes between two or more ports. Or newly renewables-rich countries such as Chile, Morocco or South Africa could seek to exploit their new energy source by making favourable agreements with operators or charterers."

With cheap fuels and no legislative penalties for inefficiency, there is currently no significant financial incentive for major change. However, May 2021 saw an IMO working group agree a set of draft guidelines to support mandatory measures to cut the carbon intensity of all ships. Among these, the introduction of a carbon intensity index will force improvements (or scrappage) on the worst performing vessels. In addition, the EU's 'Fit for 55' package will mandate improvements at a fleet level.

Could end-user pressure be the key to bringing about change? More organisations, especially those that are consumer-facing, are targeting net zero – this will be impossible if they are forced to ship items using existing fossil fuels. Global manufacturing is underpinned by shipping; if positive moves are not made quickly towards reducing climate impacts, the 'manufacture globally, sell globally' paradigm is at risk.

"The sector is under no illusions that it has to decarbonise," says MacLean, "but it is far from straightforward and unlikely to be cheap. Rather than a sudden switchover, we expect forward-thinking operators, owners, ports and fuel suppliers will collaborate to make use of financial incentives to co-develop cost effective routes which demonstrate the possibilities. What is clear, though, is that it's no longer a question of 'if' the sector changes, but 'when'."

[1] iea.org/reports/international-shipping
[2] bit.ly/3wvEzfb

A number of future fuels could become viable for decarbonising shipping

SEA CHANGES

Ricardo's teams are involved in a range of projects to reduce the maritime sector's environmental impact

MODELLING SYSTEM FOR ZERO-CARBON TRANSITION

The £500,000 NEPTUNE project, funded by the Department for Transport and delivered in partnership with Innovate UK, is developing a desk-based decision modelling and support system tool to analyse, scope and develop plans for supporting the transition of the Shetland Islands' maritime industry to zero-carbon fuels.

Ricardo is developing a 'digital twin' of representative marine vessels and assessing the islands' port energy infrastructure to facilitate the testing of different scenarios, energy flows and emissions impacts for vessels from 'well to wake'.

NEPTUNE aligns with project ORION, set up in April 2020, which is helping turn Shetland into an international clean energy hub as part of ambitious plans that will see major oil and gas fields become net zero by 2030.

FUEL CELL FOR CRUISE SHIPS

Ricardo is helping a world-leading cruise line operator to decarbonise its future vessel fleet. The project will deliver a multi-megawatt hydrogen fuel cell system to enable zero carbon emissions in port operations and navigation.

The fuel cell system is designed around the customer's needs for packaging and will benefit from Ricardo's design approach for multi-stack fuel cells to ensure high efficiency at the megawatt scale required.

With off-the-shelf products not meeting the customer's requirements, Ricardo's status as supplier and technology agnostic means the company could propose a solution that proved to be fit for purpose.

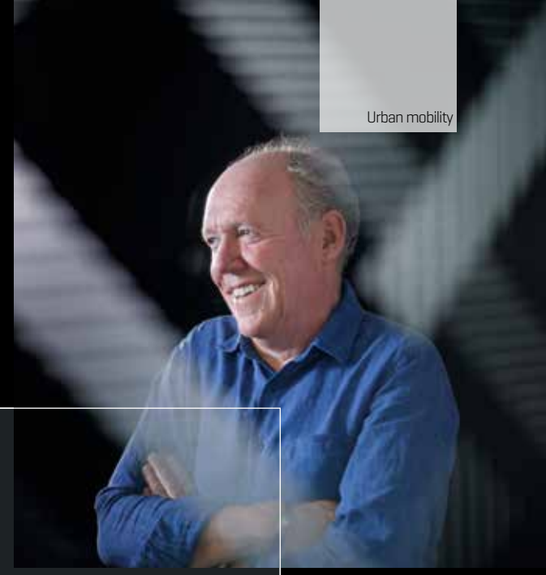
DECARBONISING FERRIES

The £2.2 million Hydrogen in an Integrated Maritime Energy Transition (HIMET) project is exploring solutions for decarbonising ferries as well as shore-side activities in Scotland's Orkney Islands.

Part of a consortium led by EMEC Hydrogen, Ricardo is designing and developing the combustion system and engine hardware to convert an existing natural gas engine to 100 per cent hydrogen operation. The engine is being updated and tested in the new hydrogen engine test facility at Ricardo's Shoreham test centre.

The project is funded under the Department for Transport's flagship Clean Maritime Demonstration Competition, in partnership with Innovate UK.

Urban mobility



HUB FOR A CHALLENGE

Two years have passed since **Ian Callum** – one of Britain's most celebrated car designers – launched his own design and engineering consultancy. CALLUM'S core business is automotive but, as **Ian Adcock** discovers, being invited to develop an urban mobility hub has proved to be a fascinating departure.

Mobility hubs are being rolled out in towns and cities across Europe as environmentally friendly travel becomes a priority for public authorities and citizens alike. In September 2020, at the Micromobility UK conference, Transport for West Midlands (TfWM) unveiled its own mini-transport hub comprising modular components which can be assembled to reinvent how parking bays and small public spaces can be used to offer better connections and shared facilities for the community.

The concept was part of the West Midlands' £22 million Future Transport Zone programme, set up to harness the latest technology and data to design accessible and connected transport alternatives that are faster, cleaner and greener.

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TfWM, which is part of the West Midlands Combined Authority, worked with Warwick-based CALLUM to develop the concept and manufacture the prototype with partners including e-scooter hire company Voi, West Midlands Cycle Hire and electric mobility charging specialist LOCKEM.

RQ: What brief were you given?

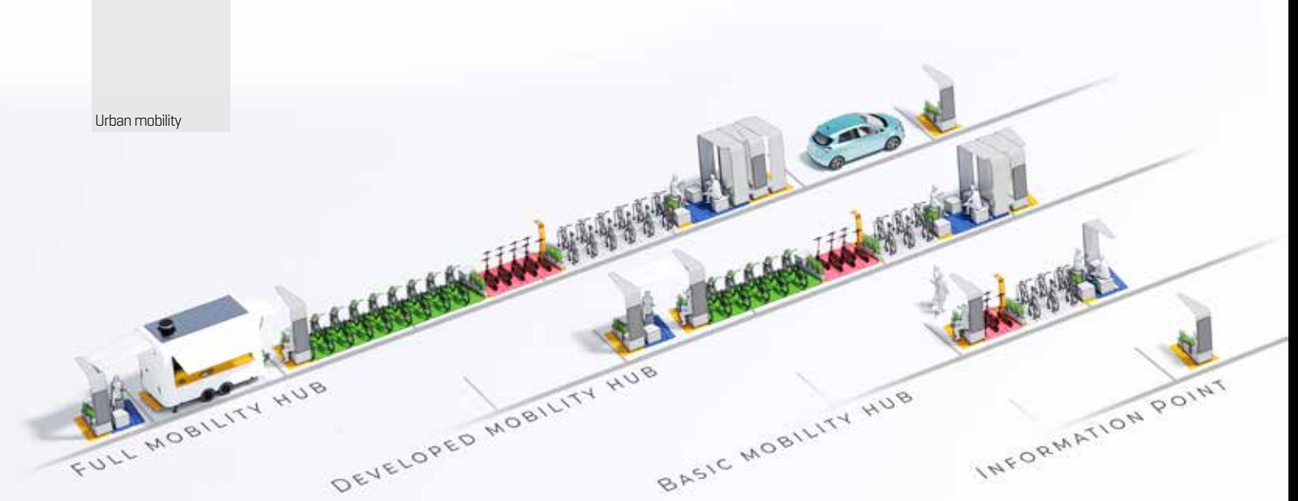
IC: "We were asked to come up with ideas that would help with forms of socially acceptable transport, whereby people could leave home for their journey and there would be bikes, electric scooters or information and a link to other transport solutions that weren't a car for the last leg. It's a departure from what we normally do but was certainly an interesting challenge.

"It was a wide-open brief, which might sound great but can leave you second-guessing a lot of the time. We discovered that as soon as you put something on paper in front of people, you can better focus on what they want and what they didn't know they knew before. These conversations were a very important part of trying to extract the reality of the brief.

"We were on a pretty tight schedule of around six months but the team's used to that from working in the automotive sector. Even so, it did involve a few all-nighters to meet the deadline."

RQ: The trouble is that these concepts can be idealistic visions of technical and societal solutions that don't or can't exist...

IC: "Absolutely. Our job was to try and pull the art of the possible out of the people we worked with. We were trying not to do the art of the impossible; there was a degree of realism from the outset: a scooter, bike or whatever for the day and



Urban mobility

IAN CALLUM CBE FRSE

- Aged 14, submitted a car design to Jaguar in the hope of landing a job.
- Studied at Lanchester Polytechnic School of Transportation Design, Aberdeen Art College and Glasgow School of Art. Master's degree in Vehicle Design (sponsored by Ford), Royal College of Art.
- 1979-1990: Design Manager, Ford.
- 1991-1999: Chief Designer and General Manager, TWR Design. Responsible for designing the Aston Martin DB7, the car for which he is most celebrated.
- 1999-2019: Director of Design, Jaguar.
- 2018: Elected Fellow of the Royal Society of Edinburgh.
- 2019: Appointed Commander of the Order of the British Empire for services to the British car industry.
- 2019: Founded independent automotive and product design agency CALLUM.

"THERE IS A HUGE AMOUNT OF SCOPE FOR CREATIVITY AROUND 'LAST MILE' TRAVEL"
IAN CALLUM

maybe an electric vehicle (EV) at some point in the future. So it wasn't flying electric taxis or anything like that, not on this occasion anyway!

"When you're doing this sort of project, you have to find a balance between your ideas and how much can be produced in the given timeframe. Because we're used to building things as complicated as cars quite quickly, we managed to produce a lot in the short space of time we had."

RQ: What about the design itself and materials used?
IC: "Effectively, it's a new form of street furniture. It's not rocket science to come up with a new concept that attracts people to use them.

"When I walk round a city and see a turquoise line on the pavement that says: 'This is where you park your city bike' or 'This is where you leave your scooter', it's really lacking a sense of purpose, presence or importance. What this project does is give all these items a sense of importance.

"We started off using container units, which I really liked. They are quite on-trend now for many different applications and, technically, they're quite mobile. However, they were too big as one of our constraints was that the mobility hubs had to fit into an average parking bay of 2.4 x 4.8 metres or multiples thereof.

"Another constraint was visibility in and around the containers as the hubs are destined for areas where anti-social behaviour can be an issue. We had to avoid creating blind spots or causing other negative issues. We also wanted to bring plots of nature into the site, which is admirable but somewhat impractical to plant a tree in the middle of a street and also make it vandal-proof."

RQ: Do you see a realistic future for modular concepts like this?
IC: "Yes, there are plenty of ideas out there and perhaps for uses other than mobility. The concept could work as a space for social gatherings or public services.

"What the project has achieved for CALLUM as a business is to force us to be quite liberal-minded about what we do. Yes, we love our cars and the rest of it, but we have learned that we can get involved in an eclectic mix of projects; we've already had a few enquiries from councils for similar approaches and applications.

"If we were to get the chance to expand on this concept it's certainly something we would embrace. There is a huge amount of scope for creativity around 'last mile' travel."

RQ: You mentioned your core business and passion for cars. How will powertrains of the future impact your role as a designer?
IC: "Most people these days don't care how a car is driven so long as it's convenient. I think EVs are an inevitability. However, I do think people get confused with interiors: 'it's an EV therefore it has to have an iPad-style control module', which is utter nonsense. The electric drive has nothing to do with the interior and how it's laid out. I think we will see a pushback against the iPad-style systems where we will get separated systems and points of information which is much safer.

"I always had this issue at Jaguar, where there was a push to put all the features and functions on a single big screen in the middle of the car – which is in the wrong place for a start and just too complicated when driving quickly."

RQ: And the exterior?
IC: "There's more design freedom with an electric platform. What frustrates me is that it can open up a whole new set of shapes and designs because it's less restrictive, yet the EVs I see are based on conventional silhouettes with a long bonnet and so on. Some argue it's for crash requirements, but not all of it: it's a case of designers feeling a need to do something that's recognisable."

RQ: How do you factor material recyclability and the circular economy into what you do?
IC: "This is driven by our clients. There's an expectation of sustainability from them. For every project we're asked: 'What's the sustainability story?' Our clients want to tell that story up front because they know people will listen.

"I have quite a young team working for me, for whom these questions are front and centre. We start each piece of work by considering how can we achieve our aim without taking any more out of the earth."

FASTER, CLEANER, GREENER

ADAM DONFRANCESCO, ENGINEERING DIRECTOR

"One of the biggest requirements for the concept is that street furniture needs to be super robust and we needed to have that same robustness.

"The flooring sections are one of the more interesting solutions we developed. They're interlocking triangular shapes which needed to be non-slip, durable and weatherproof, so we ended up using the same moulded rubber used in playgrounds. We actually took control of that in-house, embedding the inserts with our colleagues laminating and moulding components as well as developing the inserts, resins and perfecting the radii to achieve what we wanted.

"The final structural materials would depend on the quantities being manufactured. For instance, the forms are essentially encapsulated frames with mouldings using recycled plastics and natural aggregates for the shelters while the flooring uses recycled tyres and other parts are partially or fully recycled plastics."

ALECK JOENS, CREATIVE LEAD

"The West Midlands is the worst area in the UK for the 15-minute journey with only one person in the car. One element of the brief was that these hubs were designed to go into deprived communities, to take people out of cars and put them into these micro-mobility solutions so they didn't have to sacrifice income for a car.

"We wanted to make it feel as if these communities were involved in the creation of the hubs. We wanted to provide them with a toolkit with the coloured mats giving a clear idea of where each solution goes, the green mats being for bicycles and so on.

"That gives the community a kit to construct what they need in their local area: if there was an overwhelming need for bikes they could be partnered with, maybe, some seating and an information board. Likewise, if they didn't want many bikes but preferred somewhere to meet then there's the option to have a series of seats."

Changing tracks

Rail is the most sustainable high-volume mode of transport. *RQ* explores projects across Europe where Ricardo is helping to create networks that are safe and efficient as well as clean and green.

From Lisbon to Paris via Athens, Bucharest and Prague sounds like the leisurely itinerary of a gap-year backpacker. It was in fact the route for the Connecting Europe Express, a whistlestop train tour of 70 cities in 26 countries over five weeks to promote the benefits of rail for passengers, freight and the environment.

The excursion was a feature of the European Year of Rail, which ended in December. Efforts to integrate and modernise the European network are essential to drive a modal shift from roads to rail, in order to support the European Union's (EU's) Green Deal aim of becoming climate-neutral by 2050.

Rail accounts for only 0.4 per cent of greenhouse gas emissions from EU transport. Over the last 30 years it's the only mode to have consistently reduced its emissions and energy consumption while increasingly using energy from renewable sources.

Ricardo provides technical expertise, assurance and specialist engineering services to help governments, operators, infrastructure managers and manufacturers navigate the operational, commercial and regulatory demands of the rail industry.

In this special feature we catch our own trans-Europe express to see how Ricardo's teams are supporting the development of a high-functioning infrastructure to move people and goods around the continent efficiently, safely and sustainably.

UK
First hybrid battery-diesel train in service

The HybridFLEX programme saw a Rolls Royce Motoren- und Turbinen-Union (MTU) hybrid drive fitted to a multiple diesel unit to create a vehicle that can switch seamlessly between battery and diesel power. This means that when passing through residential areas or approaching station stops, the train can change to battery power to reduce noise levels and operate with zero emissions.

Modelling of the Class 168 train on Chiltern Railway's London to Birmingham route has also shown potential reductions in fuel consumption of up to 20 per cent, lower maintenance costs and faster journey times due to enhanced acceleration.

Ricardo was appointed by rolling stock owner Porterbrook to provide engineering support for integration of the mechanical, electrical and critical controls systems of the hybrid powerpack, and to oversee certification and approvals ahead of the test run programme in spring 2021 and launch last summer.

Improving infrastructure

LATVIA
Fleet of 32 new dual electric trains

New 1520mm gauge trains will replace the current electric fleet operated by Pasažieru vilciens, the only passenger-carrying railway company in Latvia, as part of a €242 million boost to the country's rail infrastructure. Each 109-metre train seats more than 400 passengers and is capable of speeds up to 160 kilometres per hour.

The new rolling stock will be able to run on both existing 3kV DC current and, as a future option, 25kV AC overhead electrification.

Ricardo's €1.8 million contract for procurement and commissioning support runs until the end of 2023, when all 32 trains are scheduled to have been delivered. The work includes inspecting the manufacturing process and technical documentation during vehicle production by Škoda Vagonka, supervising acceptance testing for handover and support with performance verification and warranty issues.

SCOTLAND
Pantograph monitoring system fully operational

PanMon is part of a drive to increase the use of predictive maintenance methods across Scotland's rail system

The UK railway system typically experiences one 'dewirement' a month on its Overhead Line Equipment (OLE). One of the main causes is a defective pantograph – the unit mounted on the roof of a train to collect power through contact with the overhead line.

A damaged pantograph, in particular a degraded contact strip (the carbon surface that connects to the wire to draw down power), can inflict significant wear and tear on OLE. In extreme cases it can tear down the wires, forcing entire route sections to close. The cost of each incident is estimated to be around £1 million, and considerably more on high frequency routes or major junctions.

PanMon is a remote condition monitoring system provided by Ricardo to protect OLE. High-definition cameras capture 3,000 frames per second, meaning even trains travelling at their highest speeds are photographed at 8mm intervals. Lasers scan the full width of the pantograph to measure its symmetry and the condition of the carbon contact strip. Using the data gathered by PanMon's cameras, railway infrastructure managers can identify defective pantograph units.

In 2019, Network Rail Scotland commissioned Ricardo to install PanMon at targeted locations across its network as part of a drive to increase the use of predictive maintenance methods across day-to-day operations. The rollout was completed in November 2021, with units installed on some of Scotland's busiest routes, including the East and West Coast lines and Edinburgh to Glasgow line.

Operating with an average accuracy of more than 99.5 per cent across each site, the cameras scan 50,000 pantographs each month. Collectively, they capture images at least once a day of every single pantograph travelling on the routes where PanMon is keeping watch.

DENMARK
Europe's largest re-signalling project

Almost half of Denmark's signalling technology is more than 50 years old. The ageing systems are reckoned to cause around half of all delays on the network.

A €3.2 billion programme to replace all signalling on Banedanmark's national lines – more than 3,000 kilometres of track – is the largest of its kind in Europe. When it's completed by 2029, Denmark will become the first country in Europe fully to adopt the European Rail Traffic Management System (ERTMS) – a single signalling and speed control system that ensures interoperability of national railway systems across the continent.

The introduction of ERTMS involves the removal of all lineside equipment, with train movements managed by central control centres communicating directly with the train and its driver via in-cab equipment. This will allow higher speeds, shorter headways, improved safety, significantly reduced signalling-related delays and full interoperability in accordance with European standards.

Ricardo experts are providing assurance services on the re-signalling project until it's completed. Delivered primarily through the company's office in Copenhagen, the work also involves assessors with relevant competence and experience from the UK, Netherlands and Spain.

ANDY IN BRIEF

Title: Hydrogen Fuel Cell Systems Service Leader, Ricardo
Background: Master's degree in Mechanical Engineering, Manufacturing and Management, University of Birmingham; Executive MBA, London Business School; joined Ricardo in 2012

A day in the life...

ANDY ENNEVER

Hydrogen fuel cell bus demonstrator project director

In March 2021, the UK Government unveiled its masterplan plus £3 million in funding for the country's first-ever hydrogen transport hub, in the Tees Valley. Bringing together experts from government, industry and academia, it's a focus for research, testing and trials across all modes of transport.

As well as serving as a 'living lab' to help us better understand the role hydrogen will play in meeting our 2050 net zero ambitions, the hub will also play a role in informing future investment decisions and export opportunities.

The Tees Valley is at the forefront of innovation in clean energy. The region already produces more than 50 per cent of the UK's hydrogen and there's significant investment in offshore wind manufacturing and carbon capture utilisation and storage technologies.

Real-world pilots could see retailers, warehouse operators and delivery companies using hydrogen-powered transport to move goods and carry out last-mile deliveries. The aim is for the hub to be fully operational by 2025, potentially creating up to 5,000 new jobs in the north-east of England.

I led the bid developed by Ricardo in partnership with Stagecoach, one of the UK's main public transport operators, to demonstrate a retrofit hydrogen fuel cell bus. We were announced as one of the competition winners last summer; since then I've been supporting our project delivery team as they design and build a one-off vehicle ready for demonstration in spring 2022.

There are 38,000 buses in service in the UK, almost all diesel powered and half less than eight years old. Bus operators need to find a long-term solution to meet the net zero targets for transport; given the typical life of a bus is at least 15 years, we've been busy at Ricardo fielding enquiries about hydrogen fuel cell retrofitting.

Battery-electric buses are now a common sight in many of our towns and cities. They're reliable, safe, use energy efficiently and have similar rates of downtime to other technologies. However, for some routes they're constrained on range, charge times can be too long and charging requirements are a challenge to power grids. This was acknowledged in the Department for Transport's long-term strategy for buses in England outside London, called 'Bus Back Better'[1], published last year. For longer journeys in rural areas, hydrogen as a power source offers greater flexibility and would allow a similar kind of operation to diesel buses. Hydrogen is more expensive at the moment but its price will fall as volume and scale increase.

The solution we're developing is modular, meaning it can be installed in different double-decker bus variants with minimal adaptation. Our retrofit solution will be around half the cost of a new fuel cell bus, so local communities get twice the saving in terms of emissions for the same amount of money.

"THERE ARE 38,000 BUSES IN SERVICE IN THE UK, ALMOST ALL DIESEL POWERED AND HALF LESS THAN EIGHT YEARS OLD"

Retrofitting also extends the life of a vehicle as the process involves replacing or refurbishing a number of high-wear items: a completely new drive line, new electric axle, new fuel cell system and more.

Given the economic, environmental and societal benefits of a circular economy, it's a win-win to extend the working life of vehicles rather than scrapping them while at the same time accelerating the conversion to zero emissions.

Furthermore, if operators combine the retrofit with a refurbishment programme, what they'll get will not only perform like a new bus, it'll look like one too. RQ

Ricardo's hydrogen expertise ranges from policy development to infrastructure feasibility through to the implementation and integration of hydrogen-based technologies for transport: ricardo.com/hydrogen

[1] gov.uk/government/publications/bus-back-better

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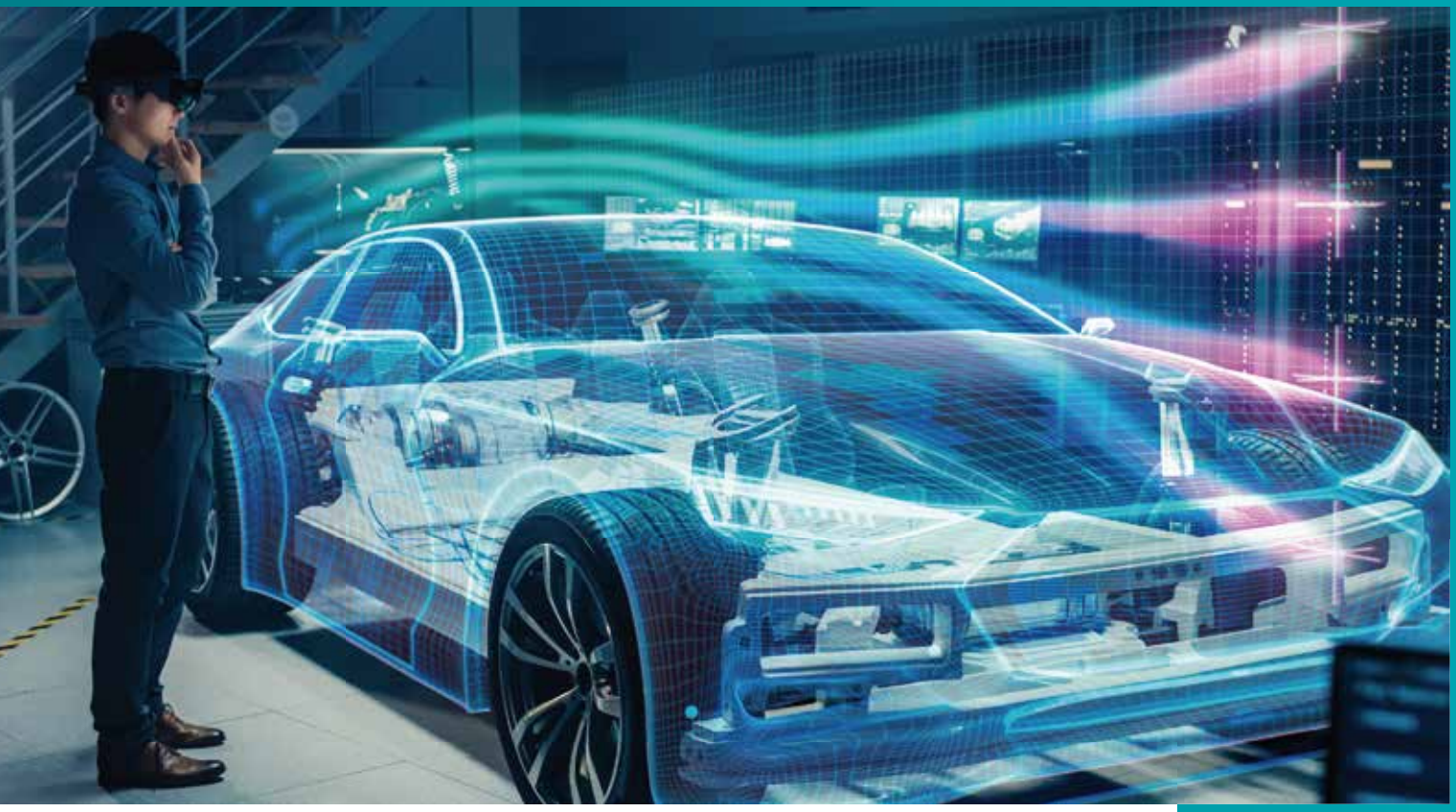
POWERING ELECTRIC FUTURES



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.

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