Ricardo Quarterly Review **Autumn** 2021

RQ

A focus on the latest in innovation, sustainability and technology

RICARDO

Catching the sun
Connecting solar electricity generation directly to the railway network

Proof positive
How negative emission technologies can help achieve net zero

Power to the people
Bringing clean energy to communities in Africa

THE WORLD IN OUR HANDS

COP26: our best chance to avert the worst impacts of climate change

RQ

CONTENTS

Ricardo Quarterly Review · Autumn 2021

RICARDO

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Forward with confidence

Outgoing CEO ***Dave Shemmans*** *reflects on more than two decades of positive change as Ricardo strives to create a world fit for the future*

(Above) **Dave Shemmans supports the delivery of Ricardo-designed protective face shields during the Covid-19 pandemic.** ***(Far left)*** **His Royal Highness The Duke of Kent visits the Ricardo Shoreham Technical Centre.**

How would you describe Ricardo as a company when you joined in 1999? And how would you describe Ricardo now?
When I joined, the company was hugely technically respected in the automotive market but geographically limited and dominated by eight clients, all leading car companies. With around 1,000 staff based in Shoreham and a business also in the US, it was a case of 'Brit-based, jump on a plane'.

Roll forward two decades and Ricardo maintains that technical respect from its 100-year heritage at the leading edge of science and technology but now applies that expertise to a multi-sector, globally distributed client base served by 3,000 people around the world. Our key markets beyond automotive now include defence, environmental consulting, performance products and rail. From a technical-focused, 'university-feel business' base in the 1990s, recent years have seen so many iconic projects around the world of which any company would be proud.

What has changed – and what brought about those changes?
I became CEO in 2005 and change has been a constant throughout my tenure: technical change, market change, political change, economic change. New start-up companies becoming clients, established clients merging or disappearing. We have seen environmental progression challenging the status quo in terms of product, from the domination of gasoline and the birth of diesel to the demise of both through electrification.

What hasn't changed are technical investment and the culture to make a difference and break boundaries. Change drives Ricardo and Ricardo feeds on that change.

What have been the key challenges during your tenure?
With such a long tenure, you do get the opportunity to navigate economic cycles – three for me, plus a pandemic. People have asked me: how do you survive such cycles and shocks? The answer is that you prepare knowing that economic cycles happen.

We have a fundamental strategy for growth and risk mitigation: no dependence on any single client, geography or sector. That, together with the recruitment of extremely talented people and a drive to make a difference, allows you to face such challenges head on and drive through them.
Through our strategy of 'no dependence' we acquired into the new related markets which shared many of the same technical issues, political drivers and legislative requirements. During the COVID-19 pandemic our auto-related businesses were hit the most while the defence, rail and environmental consulting businesses excelled. It's about that mix of GDP-related industries and businesses which benefit from government spend.

What pleased you most about the company's response to the pandemic?
The company took on all that was thrown at it and rose to the challenge. Our teams were agile and adaptable, IT colleagues provided the tools, the culture to continue to deliver great projects to clients led us through, and the enormous desire to create a world fit for the future provided the ambition and avoided us being distracted. Agility, adaptability and ambition: the critical 'three As' in any performance-focused team.

What do you believe are the keys to success over a long tenure?
Recruit great people, give them the tools and the backing, decide on your mission and commit all that you have to drive for the goal you believe in.

Everyone can make a difference and the power of companies to influence global outcomes are huge. I strongly believe it is business that ultimately decides the world's fate economically, societally and in terms of stability. If you have the privilege to lead a business, you have enormous responsibility to fulfil the mission and opportunity you have been given. Don't get side-tracked or derailed, take risks and remain agile while always being forward looking.

> *"WE HAVE A FUNDAMENTAL STRATEGY FOR GROWTH AND RISK MITIGATION: NO DEPENDENCE ON ANY SINGLE CLIENT, GEOGRAPHY OR SECTOR"*

How has engineering changed?
Engineering has changed over time in the way it is undertaken: a lot more digitalisation and use of data analytics. What hasn't changed is that it is delivered by people who are technically skilled and who want to solve problems. The physics hasn't changed, the people haven't changed – apart from the fact that we now have more women in engineering which is great – but the tools have.

COP 26 is only weeks away: how significant is this event for the business?
This year's climate-related catastrophes, with floods and wildfires in abundance, mean the world is rightly focusing on environmental solutions. This is where Ricardo squarely sits: helping governments set the right policies, helping regions set the right legislation, helping industrials meet those regulations and helping the public contribute to a greener future with reduced carbon products.

Our mission to create a world fit for the future works top down and bottom up. It's a great mission, it's a great opportunity. I am confident that I can hand over to the next CEO in a good position with a great platform for them to take forward.

RQ NEWS

Latest developments from around the global Ricardo organisation

EU climate policy package benefits from Ricardo expertise

Specialist analysis underpins new and updated measures

'Fit for 55' supports emissions reduction targets across the EU

'Fit for 55' is a package of measures to ensure the European Union (EU) can reach its goal of reducing greenhouse gas (GHG) emissions by at least 55 per cent by 2030, compared to 1990 levels. Ricardo has provided the technical analysis underpinning many of the policy measures, which have the longer-term aim of supporting Europe's ambition to become the world's first climate-neutral continent by 2050.

"Our involvement with the 'Fit for 55' package is linked to other work we are carrying out to support the European Commission, governments and industry in helping meet the EU's Green Deal objectives," says Sujith Kollamthodi, Director of Ricardo's Policy, Strategy & Economics Practice. "The overall package is very ambitious. Businesses across all sectors of the economy will need to understand the implications of each 'Fit for 55' initiative for their current and future strategies and operations.

Ricardo's teams have worked on the following key initiatives:

» **Revisions to the EU Emissions Trading System:** in-depth studies to develop and assess revised approaches to protecting the industries most exposed to carbon leakage. This work has helped the EU decide its new policy for allowance allocation and how it relates to wider competition measures like indirect cost compensation schemes and the planned Carbon Border Adjustment Mechanism.

» **Revisions to the CO_2 emission performance standards for new cars and vans:** analysis of technology costs, options for incentive mechanisms and potential impacts of tougher standards on consumers and employment. The work involved assessing the emissions abatement performance and costs of advanced vehicle powertrains and technologies that could be used to reduce future CO_2 emissions from new cars and light commercial vehicles.

» **Revision of the directive on deployment of alternative fuels infrastructure:** help to assess how successful the directive has been in supporting the uptake of electric and other alternative fuel vehicles across different transport modes, plus the impact of policy changes on accelerating deployment of the required infrastructure to achieve a more rapid decarbonisation of the EU's transport fleet.

» **Addressing GHG emissions from the maritime shipping sector:** specialists analysed possible options to incorporate maritime transport into the EU Emissions Trading System, as well as alternative options or combinations for the sector to contribute to climate mitigation efforts.

» **Supporting the decarbonisation of the aviation sector:** potential policy measures that could support the supply of, and demand for, sustainable aviation fuels in the EU while maintaining the competitiveness of the sector.

Sustainable aviation fuels projects take off

Eight industry-led projects have been shortlisted to receive a share of the UK Government's £15 million Green Fuels, Green Skies competition funding, jointly managed by Ricardo (and featured in the summer 2021 edition of RQ).

The competition for Sustainable Aviation Fuels (SAF) projects launched in March and attracted a variety of entries. The shortlisted proposals include plants aiming to produce jet fuel from:

» Carbon dioxide captured from the atmosphere with hydrogen from water;
» Alcohol derived from wastes;
» Everyday household and commercial black bag rubbish; and
» Sewage.

"We have been amazed by the diversity and creativity of the entries,' says Ricardo Principal Consultant Alexandra Humphris-Bach. "All the selected projects have a clear potential to produce SAF capable of reducing emissions by more than 70 per cent on a lifecycle basis, when used instead of a conventional fossil jet fuel."

Once the funding has been distributed, Ricardo will monitor the eight projects of behalf of the Department for Transport.

Zero emission buses for UK's first hydrogen transport hub

Government funding for a retrofit hydrogen fuel cell bus demonstrator

Earlier this year the UK Government launched the Tees Valley Hydrogen Hub and launched the Hydrogen Transport Hub Demonstration competition to showcase real-world hydrogen transport technology solutions.

Ricardo's bid to demonstrate a retrofit hydrogen fuel cell bus, submitted with public transport operator Stagecoach, was named as one of the competition winners. Funding has been awarded to build a one-off vehicle which will be available from February 2022.

There are 38,000 buses in service in the UK: 98 per cent are diesel powered and half are less than eight years old. Given the need to find a long-term, sustainable solution to meet the Government's net zero targets for transport, leading UK bus operators have already been seeking advice from Ricardo around hydrogen fuel cell retrofitting. Stagecoach has invested more than £1 billion in greener buses in the past decade.

Ricardo will develop a scalable, modular solution, enabling it to be installed with minimal adaptation to multiple single- and double-decker platforms. The concept may also be saleable as a 'new fuel cell' module to coach builders across the European Union, enabling them to develop new fuel cell buses by taking a rolling chassis and applying their coach build body alongside the fuel cell module.

"National and local governments across the UK are bringing forward their zero emissions targets to 2030," says Teri Hawksworth, Managing Director for Ricardo Automotive and Industrial (EMEA) Division. "This creates challenges for bus operators who are still grappling with the financial challenges of the pandemic but are committed to transitioning to zero-emission vehicles.

"Winning this competition means we can promote hydrogen fuel cell capabilities for buses and show the environmental, societal and economic benefits of the circular economy. Instead of scrapping vehicles, their lives can be extended through retrofitting."

Waterborne Technology Platform expands

Ricardo aids waterborne transport sector's aim for zero emissions by 2050

Ricardo has joined the Platform, which brings together most of the European waterborne transport sector including shipyards, operators, suppliers, academia, research centres and maritime associations. The collective is committed to leading the sector's research and innovation agenda and defining its strategic roadmap.

This is an opportune time for Ricardo to join, as the Platform has recently signed a memorandum of understanding with the European Commission under the framework of Horizon Europe for a co-programmed partnership. This will provide and demonstrate zero emission solutions applicable to all main ship types and services before 2030, thereby helping to make zero emission waterborne transport before 2050 a reality.

The partnership will strengthen the competitiveness of European industries in growing green ship technology markets and provide the capability to re-enter markets presently dominated by Europe's competitors.

Ricardo experts already play an active role in supporting decarbonisation of the global maritime sector, including research and development on hydrogen- and ammonia-fuelled engines; model-based development of high efficiency large-scale fuel cell systems; and innovative software tools for the virtual validation of large batteries.

Gibraltar clean air programme extended

Ricardo has won an extension of its existing consultancy agreement to manage Gibraltar's air quality and climate change programme until 2025.

The company's relationship with the British Overseas Territory dates back to 2005. Ricardo will be working with the Environmental Agency of Gibraltar to provide the air quality monitoring aspects of the programme and with the Department of the Environment, Sustainability, Climate Change and Heritage for the emission inventory and climate change programme.

"The new contract sees us expand the work with an ever-increasing focus on climate change," says Paul Willis, Ricardo Energy and Environment's Air Quality Business Area Manager, "alongside net zero action planning, projections, indicators and resilience work to meet the requirements of an ambitious government plan and Climate Change Act.

"The past two decades have provided the team with a great opportunity to deliver and develop a technically challenging, highly rewarding project. The expansion of the programme is testament to the very strong client relationship we've forged."

Ricardo tech features in UK City of Culture event

The exhibition showcases how electrification solutions can become more efficient, higher performing and cost-effective

'Our Future Moves' at Coventry Transport Museum is a major technology and innovation showcase running in parallel with Coventry's tenure as UK City of Culture – the first in a year-long series of activities highlighting the Midlands' pioneering work in transport innovation.

The exhibition highlights some of Ricardo's world-leading and world championship-winning electrification solutions for next-generation electric vehicles (EVs) and race cars, highlighting how electrification can be made more efficient, higher performing and more cost-effective:

- Ricardo Planetary Reduction Drive is part of a new family of lightweight, efficient, off-the-shelf EV transmissions, leveraging the company's experience in automotive and hypercar e-axles together with research and development for Formula E.
- Multi-speed electric drive unit concept is a highly efficient solution which allows an EV to travel for longer and further with a smaller battery.
- 800V battery concept for high performance EVs and next-generation battery management systems is designed to ensure better performance, efficiency and cost.

"With our state-of-the-art manufacturing facilities and highly skilled engineering workforce at our Midlands Technical Centre in Warwickshire, Ricardo is playing a key role in ensuring that Coventry and the wider region is recognised as a centre of innovation for future transport across multiple sectors," says Martin Starkey, Managing Director for Ricardo Performance Products.

"We hope 'Our Future Moves' will help to inspire young engineers who will be essential if the UK is to meet its net zero goals by 2050."

Events forming part of the innovation showcase continue until summer 2022 while the 'Our Future Moves' exhibition runs until 31 October.

Also in Coventry, Ricardo and electricity distributor Western Power Distribution (WPD) have combined to assess the technological and electrical usage requirements for dynamic wireless charging of commercial vehicles in the city. The project is led by Coventry City Council and funded through the Ofgem Network Innovation Allowance (NIA) mechanism.

"This technology allows electric vehicles to charge their batteries or be powered directly while being driven," explains Denis Naberezhnykh, Technical Director at Ricardo. "It would enable vehicles with demanding duty cycles to switch from petrol or diesel to being electric. This could be a game-changer as the automotive industry looks for ways to reduce its dependency on fossil fuels."

Ricardo's role includes project management and technical review of the project activities and outputs on behalf of WPD.

Adding up to victory Royal Statistical Society award for inventory team

Ricardo's work with the Department for Business, Energy and Industrial Strategy (BEIS) has been recognised with an award from the Office for Statistics Regulation and the Royal Statistical Society.

The accolade was given for 'Greenhouse Gas (GHG) Conversion Factors for Company Reporting', based on a Statement of Voluntary Compliance with the Code of Practice for Statistics. It enhances the company's reputation for accurate and comprehensive documentation.

The GHG factors output is part of the National Atmospheric Emissions Inventory (NAEI) programme that Ricardo delivers under contract to BEIS and the Department for Environment, Food and Rural Affairs. The corporate reporting factors have been developed over more than a decade of work with BEIS.

These GHG factors are the building blocks for accurate, complete reporting of GHG emissions by companies in the UK. They cover all sources that companies may have to consider in developing an emissions inventory or carbon footprint.

Meanwhile, the NAEI is a world-leading national inventory and experts from Ricardo are routinely invited to participate on international panels and teams to drive up GHG data quality and lead reviews of national reports to the UN Framework Convention on Climate Change.

"We're always seeking to keep pace with new technologies and emerging new fuels," says Eirini Karagianni, Ricardo's manager of the GHG Conversion Factors team. "The management and improvement of the GHG factors is one element that makes it a leading-edge output, worthy of this award."

Support for greener trucking in Mexico

Leading role in international consortium seeking to reduce freight emissions

Mexico's commitment to reducing greenhouse gases by 22 per cent by 2030 depends on the successful decarbonisation of its transport sector, which contributes 25 per cent of the country's total CO_2 emissions. Almost all transport emissions come from road activity, chiefly the movement of land-based cargo.

Over the next 12 months, Ricardo's specialists will work with organisations including Mexico-based Centro Mario Molina and Urbanistica to provide advice to the German Agency for International Cooperation. The project will further aid cooperation between Mexico and Germany in promoting climate mitigation efforts in the south American road freight sector.

Ricardo's focus will be on regulatory guidance to the Mexican Ministry of Environment on how to implement the regulations on air pollution standards for trucks.

VIEW FROM

UK Transport Vision 2050: changes, challenges and opportunities

Indro Mukerjee, Chief Executive Officer, Innovate UK

Innovate UK is part of UK Research and Innovation, a non-departmental public body. Indro Mukerjee is a highly experienced technology executive and business leader with a track record of leading innovation and technology commercialisation at businesses of all sizes across the world. He was appointed CEO of Innovate UK in May 2021.

Transport is changing. The way we power and fuel transport, levels of connectivity, digitalisation and automation in transport and consumer habits are all changing. That means we have to answer some big questions such as how much energy we need, where we get it from and how we distribute it.

Rising to meet these challenges offers great opportunities for economic growth and societal benefit – a cleaner environment, and new and more efficient ways for us all to get around and to deliver goods. To maximise the benefits we can take from these changes, there needs to be greater alignment in our vision of the future.

Changing supply chains

As transport moves to zero emissions, the way we power vehicles and vessels will radically change, bringing significant opportunities and risk for design, production and supply chains. Design and manufacture of batteries, power electronics, machine drives and hydrogen systems will drastically increase, and with it the associated value stream.

Similarly, electricity, hydrogen, ammonia and sustainable fuel will replace petroleum and create new opportunities for generation, production and distribution. These opportunities are significant in their scale – 155 TWh of electricity and 74 TWh of hydrogen in 2050 – for companies and countries.

> **"THE AIM IS TO GATHER UK GOVERNMENT AND INDUSTRY AROUND A SINGLE VISION THAT WILL INFORM THE WAY WE ALL INVEST IN THE FUTURE OF TRANSPORT"**

Greater connectivity, autonomous systems, new business models and robotics will transform transport. These products and services will be an increasing proportion of vehicle and vessel cost and value; the estimated global market size for vehicle data alone is $750 billion in 2030. This will influence our towns and cities as well as ways of working, bringing challenges and opportunities in cyber security and sovereign control of critical national assets.

Travel and transport demand

As well as incredible technology change, we also need to understand the traveller and their needs. The UK population is set to grow to 72 million by 2041 and older age groups make up a larger proportion. Online retail and home deliveries will increase from 27.9 per cent in 2020 to over 60 per cent by 2030, moving demand between vehicle types. Full autonomy on highway and in urban areas is expected by 2050 with most vehicles expected to have intelligent decision-making by the same date. These changes will mean travellers' expectations of the transport system will be significantly different in the near future.

Conflicting forecasts

This influences how much we all travel and how. Industry forecasts predict strong growth in the numbers of vehicles and vessels in use, typically 40 per cent up on 2019 levels. Scenarios laid out by the Climate Change Committee and used by organisations like the National Grid assume a reduction in travel in order to meet climate targets. This sort of misalignment makes forecasting future market sizes problematic, creating uncertainty that doesn't help any investors.

The future

To maximise our return on investment we need to make smart, informed choices and minimise uncertainty. This is particularly difficult when market segments are changing rapidly and the forecast on market size is not aligned. To succeed we need communication and collaboration to develop a joint vision of the future.

In our new 'UK Transport Vision 2050'[1] report we aim to foster a better understanding of what lies in the future so we can anticipate the opportunities and make the most of them.

The vision is an in-depth study that sets out what the UK transport system may look like in 2050 and outlines the likely steps along the way to achieving this. The aim is to gather UK Government and industry around a single vision that will inform the way we all invest in the future of transport to deliver economic growth and societal benefit. It is also to provoke debate, and Innovate UK are seeking feedback to help refine and improve the vision with regular updates.

[1] ukri.org/news/innovate-uk-launches-uk-transport-vision-2050

THE BIG PICTURE

Kuria, Migori County, Kenya

In 2013, only 20 per cent of Kenya's population had access to electricity. Six years later that figure had leapt to 70 per cent, according to the latest joint annual report from the custodian agencies appointed by the United Nations (UN) to report on progress against Sustainable Development Goal (SDG) 7 on energy.

The aim of SDG 7, as set out by the UN General Assembly in 2015, is to achieve universal, sustainable energy access by 2030. 'Tracking SDG7: The Energy Progress Report' shows that if the present rate of growth continues, the global target will be missed. Across Sub-Saharan Africa as a whole, less than half the total population currently have access to electricity.

As well as the challenge of bringing power to more people, Kenya must also grapple with its Nationally Determined Contributions, the country's planned climate actions in line with the Paris Agreement. Kenya's energy sector has been identified as a priority, with high potential to cut down emissions and contribute to a 32 per cent greenhouse gas reduction by 2030.

Specialists from Ricardo and a team from sub-contractors Kenya Climate Change Working Group are tackling both issues by partnering with the county governments of Baringo, Migori and Tana River to produce effective electricity development plans. The counties will be provided with a toolkit to develop local plans that take full advantage of available untapped natural resources including biomass, waste, solar, hydro and wind.

The plans will diversify energy production sources to reduce costs of production and enhance its reliability. They will take into account the location of the local communities (including settlements as well as public facilities such as hospitals and schools) and their current and prospective demand on the basis of realistic development opportunities. This will ensure access to affordable, reliable, sustainable and modern energy for all.

Ricardo will also promote co-ordinated new investment in low-carbon, decentralised electricity generation with a range of technological solutions, including mini-grid and off-grid.

Initial funding has come from UK Partnering for Accelerated Climate Transitions and additional resources could see the programme extend to other counties.

"This isn't just about providing power for people's homes," says Jackie Nyaoro, Ricardo Business Development Manager. "The lack of electricity creates more fundamental issues, affecting education, health and how people provide for their families. Children trying to enhance their skills or take part in educational activities have fewer hours per day to read or study because they do not have quality lighting.

"Communities without access to power have a limited ability to operate health centres at night, which is essential for pregnant women and the critically ill. Furthermore, without power, health centres cannot operate basic laboratory equipment or the fridges that store vaccinations and other items. Bringing power to these counties will considerably improve quality of life while also supporting the environment."

ZERO BALANCING

The 26th Conference of the Parties summit (COP26) will be hosted in partnership between the UK and Italy and held in Glasgow from 31 October to 12 November. **Mike Bell,** Ricardo's Group Strategy and Transformation Director, introduces this landmark event and explains how its priorities resonate with Ricardo's vision.

Overleaf, we explore UK and overseas climate change initiatives in which Ricardo has been involved and look at new energy management technologies helping towards net zero emissions.

The forthcoming UN Climate Change Conference will be attended by the countries that signed the United Nations Framework Convention on Climate Change (UNFCCC) – a treaty that came into force in 1994. COP26 is expected to create new initiatives for delivering climate action globally. As host, the UK will take the lead in negotiating new climate commitments. The COP26 President, Alok Sharma, announced five key priority areas last year:

- **Adaptation and resilience:** 'Helping people, economies and the environment adapt and prepare for the impacts of climate change.'
- **Nature:** 'Safeguarding ecosystems, protecting natural habitats and keeping carbon out of the atmosphere.'
- **Energy transition:** 'Seizing the massive opportunities of cheaper renewables and storage.'
- **Accelerating the move to zero-carbon road transport:** 'By 2040, over half of new car sales worldwide are projected to be electric.'
- **Finance:** 'We need to unleash the finance which will make all of this possible and power the shift to a zero carbon economy.'

These priorities resonate well with Ricardo's mission. Our business is actively contributing to each of these areas, from our heritage in automotive through to our environmental practices operating in critical areas impacting climate change.

Support for developing economies

Energy transition is an exciting area and we have numerous projects running. We are collaborating with AFC Energy, a leading provider of hydrogen power generation technologies, to develop products and services that will directly support energy transition. And as explained on pages 17-21, we are targeting renewable and sustainable energy management for key infrastructure, such as introducing solar to power rail networks and the development of hot air turbine technology.

We have provided the UK Government and the European Commission with policy support on road transport options to achieve zero tailpipe emissions and conducted life cycle assessment to understand the total climate and environmental impact of road vehicles. We are also supporting the Mexican Government with its plan to reduce greenhouse gas emissions in the freight sector. It is critical we do not leave developing economies behind, hence we are helping Bangladesh to access finance to invest in new electric vehicles as part of the UK Partnering for Accelerated Climate Transitions programme, which was featured in the Summer 2021 edition of *RQ*.

Our automotive divisions are actively supporting customers on their electrification journey. We have experience in power electronics, machines and drives, as well as batteries. Our work is not just with vehicle manufacturers: we recently won a contract with LS Automotive Technologies to develop a state-of-the-art high voltage DC-DC converter to power the low voltage network in an electric vehicle.

Hydrogen fuel cells will also play a part – more likely in long-haul and off-highway vehicles. As an example of our expertise, we have assisted Toyota in the design, testing and development of several Class 8 heavy duty zero emissions fuel cell electric trucks from our Detroit campus.

Rising to the global challenge

The delay in COP26 by a year has meant key international agreements and decisions have been postponed, which is obviously concerning. However, we now have the benefit of the Sixth Assessment Report from the Intergovernmental Panel on Climate Change (IPCC)[1], which brings us up to date (the last one was published in 2014) on the current state of climate change through the consensus of international scientists.

We also have the change in sentiment from many governments in response to the COVID-19 pandemic, with stimulus programmes aimed at building green economies.

The IPCC report, published in August, is not the easiest of reads but it contains many stark findings and is certainly a call for action. For example, in 2019, atmospheric carbon dioxide concentrations were higher than at any time in at least two million years and concentrations of methane and nitrous oxide were higher than at any time in at least 800,000 years. Global surface temperature has increased faster since 1970 than in any other 50-year period over at least the last 2,000 years.

A successful COP26 is critical for all of us. For many people, COVID-19 has refocused priorities and caused individuals and governments alike to pay closer attention to the environment. The UK is showing leadership on the world stage with COP being held for the first time on our shores. It is a truly global challenge, and Ricardo is rising to the challenge of supporting governments and clients around the world to meet the Paris Agreement goals to keep the rise in global temperature below 2°C, with eyes on a 1.5°C limit.

ukcop26.org

[1] ipcc.ch/assessment-report/ar6

"GLOBAL SURFACE TEMPERATURE HAS INCREASED FASTER SINCE 1970 THAN IN ANY OTHER 50-YEAR PERIOD OVER AT LEAST THE LAST 2,000 YEARS"
MIKE BELL

A successful COP26 is critical, not least because COVID-19 has refocused priorities and caused individuals and governments alike to pay closer attention to the environment

THE WORLD AT ONE

The Paris Agreement of December 2015 charted a new course in the effort to combat global climate change. This legally binding international treaty was adopted by 196 parties at COP21 in Paris and required countries not only to make commitments but to progressively strengthen them. Its goal is to limit global warming to well below 2°C, and preferably to 1.5°C, compared to pre-industrial levels.

Ricardo supported policymakers from more than 15 countries to put forward ambitious but fair climate commitments (known as Intended Nationally Determined Contributions or INDCs) that reflected each country's development goals. A country's INDC is converted to a Nationally Determined Contribution (NDC) when it formally ratifies the Paris Agreement.

Since COP 25, held in Madrid in December 2019, Ricardo's multidisciplinary teams have continued to support more than 20 countries with the delivery of climate change projects and implementation of their NDCs.

Our map highlights some of the locations where Ricardo has been involved, with projects including national plans for medium- and long-term climate adaptation planning; climate finance plans to enable countries to raise investment from public and private sources; and specific action plans for sectors such as energy and transport.

1 KENYA: Ricardo supported Kenya's INDC process, including cross-departmental consultation within government and with key stakeholders; data collection; and analysis of the mitigation and adaptation options to be considered within the INDC. Ricardo's teams also drafted the INDC itself.

2 NAMIBIA: Support in collecting private sector data for the country's GHG inventory.

3 NIGERIA: Support for Nigeria to produce its INDC, including determining a reasonable mitigation contribution and assessing the potential mitigation benefits of measures aimed at climate adaptation.

4 ZAMBIA: Review of the GHG inventory for energy (coal), transport and waste as part of Zambia's NDC update, as well as analysis to identify the costs of implementing the adaptation component of its INDC.

Ricardo worked with the C40 Cities Climate Leadership Group to support nine African megacities in delivering their country's Paris Agreement goals

8 PALESTINE: As the basis for Palestine's NDC, Ricardo developed a comprehensive national GHG inventory; assessed the mitigation potential of sources and sinks across all sectors; and developed the country's national adaptation plan, including a systematic identification of vulnerabilities and adaptation options.

9 CHINA: Ricardo hosted a study tour by a delegation from the China Electricity Council to discuss estimating and reporting installation-specific GHG emissions.

10 NEPAL: Ricardo's review of Nepal's GHG inventory focused on agriculture, forestry and other land use, supported by a programme of training and technical support for improvements.

Tropical deforestation causes warming locally, regionally and globally, while changing rainfall by altering the movement of heat and water

5 CHILE: Ricardo reviewed Chile's GHG inventory and delivered a programme of training and technical support for improvements. Work also included the design of a carbon budgets framework and an agreed design for measuring progress both against the carbon budgets and towards Chile's NDC targets.

6 COLOMBIA: As well as reviewing Colombia's GHG inventory, Ricardo's teams delivered technical assistance to the country's Government on how to align emerging carbon market opportunities under Article 6 of the Paris Agreement with its NDC implementation strategy.

7 MEXICO: Ricardo reviewed the country's GHG inventory component of its INDC.

Standing room only at COP21 in Paris as Ricardo was supported at a side event by countries for which it had delivered INDCs

One in three people across Africa face water scarcity as climate change makes rainfall more erratic

11 BRUNEI DARUSSALAM: Work for this small equatorial country on the northern coast of Borneo identified the most suitable mitigation and adaptation options for its INDC; analysed cross-sector options involving energy, transport, waste, forestry, land use and health; and included a high-level vulnerability assessment to confirm the areas most at risk from future climate changes.

12 BANGLADESH: Ricardo reviewed the country's GHG inventory and delivered a capacity-building workshop on how to improve it. The company also supported Bangladesh's INDC process with a review of projected emissions, potential mitigation options and scenarios; and a study of the synergies between mitigation and adaptation and economic development, including the potential impacts on gender and alleviation of poverty.

Ricardo's work with Bangladesh included the impact of climate mitigation measures on alleviation of poverty

THE LANGUAGE OF CHANGE

Carbon sink

Anything that absorbs more carbon from the atmosphere than it releases. Forests are natural carbon sinks, taking carbon out of the atmosphere through photosynthesis. Likewise, the world's oceans absorb a large amount of carbon dioxide from the atmosphere.

Greenhouse Gas inventory

This is an accounting of seven greenhouse gases (GHGs) emitted to or removed from the atmosphere during a given period: carbon dioxide (CO_2) methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3).

Reporting of national inventories is part of the management and monitoring of GHG emissions by the United Nations Framework Convention on Climate Change (UNFCCC). Ricardo has operated the UK Government's emissions inventory programme and GHG reporting for more than 30 years, earning recognition from the UNFCCC for its completeness. The company also supports countries through direct compilation of their national inventories; by helping them establish their own compilation systems; and by developing their inventory reports.

Nationally Determined Contribution

The Paris Agreement requested each country to outline and communicate its post-2020 climate actions, known as a Nationally Determined Contribution (NDC). This is a country's chance to translate its climate goals into the policies, financial commitments and measures by which emissions are reduced and climate resilience enhanced. NDCs are established independently by countries or regional groups of countries and are non-binding. However, they are set within a binding framework designed to ratchet up climate action over time. NDCs are expected to be updated on a five-year cycle.

NET BENEFITS

Negative emission technologies have an increasingly important part to play in the quest for net zero. *RQ* reports on a collaboration between Ricardo and Bluebox Energy to design a community-scale greenhouse gas removal system.

Some industries are almost impossible to decarbonise completely. If we are to achieve net zero, residual emissions from the likes of cement, chemical and steel manufacturing need to be counterbalanced by the active removal of CO_2 from the atmosphere. This is where negative emissions technologies (NETs) come in – to 'suck' greenhouse gases out of the air to compensate for their ongoing release within the most challenging sectors.

What level of negative emissions is needed? Estimates for the UK vary from 30 to 130 megatons of CO_2 per year, the equivalent of between 10 and 37 per cent of current annual emissions.

There is, however, Government recognition of the potential value of NETs, with up to £100 million of innovation funding and a £1 billion carbon capture, utilisation and storage (CCUS) fund. The latter will equip two of the UK's major industrial clusters with infrastructure for capturing, transporting and storing CO_2 by the mid-2020s, with two more clusters targeted by the end of the decade.

Maximising carbon capture

Since 2014, Hampshire-based Bluebox Energy has been developing ultra-low carbon combined heat and power (CHP) solutions for homes, business parks and agriculture. CHP is an energy-efficient technology that generates electricity and captures the heat that would otherwise be wasted to provide thermal energy.

Bluebox Energy's technologies include a new method to convert heat to electricity using a hot air turbine which takes in filtered air and compresses it in a turbo-compressor. This air is heated using energy from a hot gas stream, such as flue gas from the combustion process. The hot pressurised air then passes through the turbo-compressor and power turbine to produce electricity.

The electrical output from the turbine generator is converted to grid power in a dedicated inverter. The air emerging from the power turbine is still at a temperature of around 400°C so can be used for heating, steam production or direct drying.

In 2019, Ricardo and Bluebox Energy began to explore the potential of biomass pyrolysis as an ultra-low carbon solution. Biomass is renewable organic material such as wood and crop waste; pyrolysis is the decomposition of that organic material at a high temperature in an inert atmosphere.

The charcoal that results, known as biochar, can be used as animal feed or to enrich soils. The carbon in the biochar is very slow to break down, which means the carbon it absorbed from the atmosphere while it was still biomass is locked up for hundreds or even thousands of years.

As Jonathon McGuire, Chief Executive Officer of Bluebox Energy, explains: "This project perfectly combines the expertise of Bluebox Energy and Ricardo. First, we had Bluebox Energy's concept of capturing 50 per cent of CO_2 in biochar (resulting from pyrolysis using a hot air turbine CHP system) with the other 50 per cent released into the atmosphere. Second was Ricardo's belief that most of the 50 per cent emitted could also be captured using chemical absorption.

"Achieving this would allow us to capture 90 per cent of the remaining emissions and, as a result, increase the overall CO_2 capture to 95 per cent of total emissions."

Attracting carbon credits

A current drawback of most negative emission technologies is that they are only considered viable for large-scale emission sources such as power and industrial plants. Earlier this year, however, Ricardo and Bluebox Energy won funding through the Net Zero Innovation Portfolio to design a greenhouse gas removal system that could operate at a community scale.

Known as BIOCCUS, the system works by taking sustainably sourced waste wood from domestic timber production and then processing it in three ways: producing biochar; generating heat and power; and capturing and storing the CO_2. The technology captures up to 95 per cent of the CO_2 absorbed by the trees; commercially marketable biochar can be used in farming; and the CO_2 can be deployed for low-carbon concrete. All of which attract valuable carbon credits that can be traded.

This first phase of the project lasts until December 2021 and could potentially lead to the consortium being selected to develop a prototype and demonstrate the technology between 2022 and 2024. Ricardo is leading the design of the CO_2 capture system.

"Ricardo is aiming to become a world leader in integrating carbon capture with pyrolysis-based CHP systems for community-scale applications," says Dr Gareth Milton, Chief Engineer with Ricardo Automotive and Industrial EMEA Division.

"This system shows how we can achieve negative emissions while generating revenue streams for industry and local communities through waste heat and sequestered carbon products. What's more, an organisation could use decarbonised or net-negative CHP technology to improve its own environmental impacts. RQ

"We can achieve negative emissions while generating revenue streams for industry and local communities"
Dr Gareth Milton, Ricardo

Negative emissions technologies 'suck' greenhouse gases out of the air to compensate for their ongoing release within the most challenging sectors

Here comes the SUN

Ricardo is part of a consortium aiming to connect solar electricity generation directly to the railway network and provide zero carbon power cheaper than from the grid. **Andrew Shields** asks: is this the start of a radiant future for rail?

© Andy Aitchison

The solar PV array at Aldershot station connected to an ancillary transformer on the DC traction system

"PLUGGING SOLAR DIRECTLY INTO THE RAILWAYS OPENS UP OPPORTUNITIES TO USE RENEWABLE ENERGY TECHNOLOGIES IN WAYS NOT PREVIOUSLY POSSIBLE"

IVAN STONE, CEO, RIDING SUNBEAMS

"At its core," says Ivan Stone, "this is a simple idea. But you have to remember: it had never been done before."

Four years ago, recalls the chief executive officer of Riding Sunbeams, experts from the Energy Futures Lab at Imperial College London, Community Energy South and electrical engineering specialists Turbo Power Systems gathered trackside near Aldershot station in Hampshire.

"We were there to find out whether it was possible to install a solar farm close to an electrified train track and, instead of connecting to the grid like a conventional solar array, create a direct link to the track to provide traction power for the trains."

The answer was: yes. The experiment proved that the grid could be bypassed completely. Thus was born Riding Sunbeams' mission to find an unsubsidised route to market for community energy and to decarbonise railways – Britain's largest electricity consumer – in a way that would also maximise social benefit. "Railways and solar photovoltaics (PV) are," says Stone, "a match made in heaven."

Alternatives to carbon

Transportation is responsible for around one-fifth of global carbon dioxide (CO_2) emissions. Within this sector, rail is among the most efficient and lowest emitting modes, according to a report, 'The Future of Rail', published in 2019 by the International Energy Agency.

Rail accounts for eight per cent of the world's passenger movements and seven per cent of freight transport yet uses just two per cent of transport energy demands. Three-quarters of total rail passenger movements and half of rail freight rely on electricity, making it uniquely positioned to take advantage of renewables.

Projects around the world are showing that low-carbon energy alternatives do exist and are no less efficient. Ricardo provided safety case development and certification for the mainline test of the UK's first hydrogen powered train, HydroFLEX [see *RQ* Spring 2021], while Indian Railways has equipped nearly 60 passenger coaches with solar panels to supply light and fan power since 2017. The station at Guwahati in Assam is 100 per cent solar powered and solar PV installations are planned at 8,500 more stations in the coming years. Similar projects are underway in Australia and Argentina.

Founded by climate charity Possible and Community Energy South, the aim of Riding Sunbeams is to take solar potential a significant step further, in the belief that direct supply to rail traction systems opens up opportunities for decarbonising metro, tram and railway systems everywhere. Ricardo has been working with Riding Sunbeams since 2019 on solutions for systems at each stage of the proposition.

Overcoming technical challenges

Thirty per cent of railways are currently electrified, using either a third rail parallel to the track carrying DC power or overhead AC or DC cables. Cost is a significant factor to electrify the remaining 70 per cent; Riding Sunbeams not only provides clean power, it also reduces cost.

⇨

RIDING SUNBEAMS

The solar PV array at a demonstrator site outside Aldershot station

Deploying solar energy to power railways faces a number of technical challenges. Two-thirds of the UK's existing electrified routes – and all plans for new rail electrification – use AC overhead lines to power trains. Most of the electrified train lines around the world do likewise. The technology needed to provide low-cost power conversion from renewables to AC rail traction systems has not previously existed.

Ricardo is part of the Riding Sunbeams-led collaboration, working with Turbo Power Systems and Network Rail, that is seeking to show it's possible to create a direct connection between renewables and AC rail networks.

"With Ricardo's support," says Stone, "we will be able to apply our low-cost, low-carbon traction supply model to most of the electrified routes in the UK and around the world. This will also support low-cost electrification of some of the most challenging remaining diesel-powered lines.

"Proof of capability will bolster our attempts to enter the traction power supply market as a small and medium-sized enterprise with an innovative value proposition that can be applied in the UK and many other countries."

Indeed, a study commissioned by Indian NGO Climate Trends and Riding Sunbeams and conducted by Ricardo Energy and Environment has found that a direct supply of solar energy to Indian Railways, without the need to connect via the grid, would save almost seven million tonnes of carbon per year. It could also potentially power at least one in four trains on the national network.

Making a world-first connection

In 2019, the team successfully demonstrated a direct connection between solar PV panels and the DC third rail traction system. That summer, a test unit of just over 100 panels was installed next to the track at a demonstrator site outside Aldershot station. Named 'First Light', this was the first time in the world that renewable zero carbon electricity had been directly supplied to an adjacent rail line without causing either system to malfunction.

The 30 kilowatts peak (kWp) unit was connected to an ancillary transformer on the traction system of Network Rail's Wessex Route, with the energy captured from the panel array used to power signalling and lights. Ricardo provided its expertise in power generation research and experience of connecting renewable energy technologies to existing DC third rail infrastructure.

"Taking our idea off the drawing board and onto the tracks was a pivotal moment," adds Stone. "We've shown that plugging solar directly into the UK railways can be done safely and without disruption to train services and opens up opportunities to use renewable energy technologies in ways not previously possible.

"At the same time we have been gathering electricity demand data from potential community solar farm sites in the south of England. By putting this real-world data together, we'll be able to work out how to plug in much larger solar arrays to power trains in future."

The model allows transport system operators to buy competitively priced low carbon energy directly from a community solar farm. Riding Sunbeams estimate that each megawatt (MW) of solar capacity connected to the rail traction system will deliver annual savings of around 245 tonnes of carbon dioxide equivalent (CO_2e).

Projects in the pipeline

Late last year, Riding Sunbeams secured funding from Thrive Renewables and the Friends Provident Foundation to develop a pipeline of new renewable energy projects in south-east England and south Wales.

This was followed by a £2.5 million award from the UK government's Getting Building Fund to build a 4 MW solar farm in East Sussex which will directly power the main line railway between London and Eastbourne. Ricardo contributed feasibility insights, including financial models for delivery of the solar farm, and options for the electrical connection between the solar farm and the railway. This project will become operational in mid-2022.

Riding Sunbeams' work has informed Network Rail's Traction Decarbonisation Network Strategy as well as the Department for Transport's Transport Decarbonisation Strategy. It could ultimately see one in every ten UK trains running on energy direct from the sun.

The projects have also helped to inform both Transport for London and HS1's new tender processes to procure renewable traction energy direct from lineside generators. Last year Riding Sunbeams completed a new feasibility study with Transport for Wales for direct supply to 25 kV AC overhead electrified routes, looking at the potential for community solar to power the South Wales Metro.

"Community energy – where local people own the renewable energy and benefit from it – is at the heart of this work," says Stone. "We want to provide a commercial route to market for community energy groups looking for new projects to develop and connect them to regional rail network operators like Network Rail who will pay a fair price for their power.

"Our mission is to see community- and commuter-owned solar farms powering the railways – for the benefit of the railway routes, the communities that host them and of course the planet. Get on board - here comes the sun!"

FROM CLIMATE SCIENCE TO PUBLIC POLICY

Gill Wilkins is Principal Consultant: Climate Change, Energy and Development at Ricardo Energy & Environment and Programme Director for CS-NOW. Her technical expertise includes mitigation, adaptation and climate funds as well as measurement, reporting and verification systems.

Gill Wilkins introduces the new research project 'Climate Services for a Net Zero Resilient World' (CS-NOW)

A generation ago, our parents will tell us, conversations about the weather focused on cloud, drizzle and the newspaper predictions of endless sunshine that sadly failed to materialise. Now, floods, heatwaves and extreme storms are all-too frequent headline stories and a worrying reality for communities throughout the UK and across the world.

The effects of climate change are already being felt. According to the Met Office's State of the UK Climate report for 2020, last year was the third warmest, fifth wettest and eighth sunniest on record.

I am programme director of a new £5 million research project launched to step up the UK's resilience to the impacts of climate change. The high-quality scientific insight and analysis that will emerge from 'Climate Services for a Net Zero Resilient World' (CS-NOW) will provide the backbone needed to drive forward the UK's response to the impacts that a warming planet will have on our nation's infrastructure and be at the heart of future policy.

Making evidence-based choices

Ricardo is leading a consortium of internationally renowned universities and research institutes in this ground-breaking four-year programme. Our aim will be to provide the evidence needed to underpin climate change policy and raise ambition internationally. It's a key step in the UK Government's commitment to limit global warming to within 1.5 degrees and reach net zero emissions by the middle of this century.

The year 2020 was the UK's fifth wettest on record

> "CS-NOW will provide the right tools and the most up-to-date information to ensure we make the best possible choices"

The stark fact is that climate decisions taken by the Government now, and over the crucial next few years, are of vital importance to protect our homes, our wellbeing and our country's future. CS-NOW will provide the right tools and the most up-to-date information to ensure we make the best possible choices.

I am confident that within the consortium we have world-class multi-disciplinary scientific and research leadership, with a deep understanding of the state of scientific knowledge related to climate change. This is combined with expertise in bridging the gap between policy and science to facilitate evidence-based policy-making on decarbonisation and climate action.

Informing decision-making

By visualising data to make it more accessible, transparent and user friendly, we can help regional and national authorities understand and respond to these impacts. The Government will then be equipped to engage with local authorities on local climate action plans designed to help households cope with extreme temperatures and identify low-cost, low-carbon measures.

The CS-NOW programme will also provide models for how the UK can reduce carbon emissions globally. This will build on the UK government's work with other countries to develop decarbonisation strategies, so we can help overseas nations reduce their own carbon footprints while building resilience and protecting their populations.

Over the next four years, we will be working at the critical interface of science and policy. CS-NOW will translate research results for policy-makers that drives action nationally and that influences international climate change policy. It is a hugely exciting opportunity – but also a daunting one. The stakes could hardly be higher.

ARRIVAL TIME

As urban transportation options evolve, now is a great time for automotive start-ups to enter the arena. Arrival's **Michael Hurwitz** explains his company's innovative approach to developing commercial vehicles. **John Challen** jumps on board.

Buses and vans might not seem the most exciting modes of transport around which to plan the future of cities. That, however, is not stopping Arrival. Passenger and commercial vehicles dominate urban areas, so the UK technology start-up is looking at the topic from a very different angle. It has high hopes for electric bus and van products and the shift that it wants to bring to urban transportation.

One of the driving forces at Arrival is Michael Hurwitz, the relatively new, er, arrival at the company. The Director of Development, Mobility, came from Transport for London where, as Director of Transport Innovation, he was responsible for ensuring the capital was future-proofed when it came to transportation solutions. Now he finds himself on the other side of the fence but helpfully knows what – and, in some cases, who – he and Arrival are up against.

"Arrival's founder, Dennis Sverdlov, talks about how the idea for the company came from walking around London," recalls Hurwitz. "He thought about how to elevate the experience and also about the validity of public transport. He considered the situation from climate and inequality perspectives, which relate to the role of electric private cars in future mobility. Specifically, if everybody switches to individual electric vehicles (EVs), streets will still be congested. As a result, Arrival decided to focus on commercial and passenger-carrying vehicles."

The continuing shift to electric backs up Sverdlov's point about elevating the experience: "Delivery drivers can reduce their impact on the cities they're operating in with our vehicles. Commercial vehicles enable electrification to become a more deliverable option as the vehicles are going back to base and have a set route."

Hurwitz and his colleagues at Arrival have many different ideas for the urban environment. As the following pages reveal, he is a man with opinions about the whole urban transport spectrum – even including vehicles that are unlikely to wear the Arrival badge any time soon.

ON THE BUSES

Hurwitz believes the most efficient way of getting people around a city is by buses, mainly because they are a very efficient use of road space. "As a business, the focus shouldn't just be on private cars because there has been a shift to bus and then the van in delivery markets," he says, contemplating their rise in towns and cities in recent years. "That shift has accelerated because of COVID-19 – by as much as three to five years, according to recent statistics, on what was already a growing curve on online retail."

Post-pandemic, there's a new challenge for getting people back on buses; numbers are reported to be around 65 per cent of previous levels. Arrival knows it needs to focus on areas such as design and user experience to get passengers back.

"In simple terms, a bus is a squarish box that moves with as many people on board as possible. But there is more to it than that," reasons Hurwitz. "Our current designs have the batteries in the floor, so we can have a panoramic sunroof, for example. That lets passengers experience what's going around them. We have also got bigger windows than traditional counterparts and we've also focused on cleanliness." The cantilevered seats on the Arrival bus make cleaning underneath quicker and easier.

MATERIAL GAINS

One of the most interesting elements to the Arrival story is its innovative approach to materials. "The goal is for our fully electric vehicles to be the same cost as internal combustion engine equivalents. For that to happen, it's important to look at the manufacturing process," says Hurwitz.

"In traditional original equipment manufacturer (OEM) manufacturing processes, there are two elements that require a huge amount of capital expenditure, space and energy: the body shop and the paint shop. In the body shop, you've got giant steel multi-million-pound machine presses that have to last for many years. While the paint shop will be filled with machines that enable vehicles to get one coat of paint, freeze dried and then they're painted again."

That model wasn't attractive to Arrival. "My ingenious colleagues suggested using moulded thermoplastics because they're just as strong as traditional materials. You thereby remove the need for the body shop and the moulds are smaller and cheaper. You also remove the need for painting altogether. When the vehicle goes into service and gets a scratch, it doesn't matter because the colour is weaved into the material.

Hurwitz believes the bus is the most efficient way of getting people around a city

CELL DIVISION

Having torn up the materials rulebook, Arrival then set about revolutionising vehicle production. "We decided that instead of a monolithic conveyor belt, we would have a flexible, reconfigurable ecosystem of autonomous mobile robots – otherwise known as AMRs," says Hurwitz. "We are building a range of AMRs which have different functions, abilities and come in a variety of sizes, which can ultimately collaborate with each other to perform complex operations in the microfactory setting."

"With a production line, you have to make more than 100,000 vehicles a year for it to be worthwhile. We've got a microfactory in South Carolina, USA, that will be capable of producing 1,000 buses or 10,000 vans in a converted warehouse, with much lower set-up costs."

One important point Hurwitz raises about this model is the ability to tailor it to local requirements and build close to where the end product will be used: "It's a contrast to what we have at the moment, with OEMs investing in huge facilities around the world," he reasons.

"We have the opportunity to look at where the market is going to be, where to put the distribution centre and who the main recipient of the vehicles will be. Then we can offer local jobs, take on local skills and make local investment. It has low environmental impact and you don't have to be in the middle of a city but can operate much closer to cities, rather than being limited to big brownfield sites."

It's a model that could become commonplace. Arrival's research and development centre is in Oxfordshire, which is also home to the first UK factory. Arrival also has two microfactories in the states, as well as one in Madrid, Spain. "We've taken a modular approach to how we build our vehicles because what works in one location isn't going to work elsewhere," says Hurwitz. "South Asia is going to be different to Europe, for example, so it's essential that we work with the local markets to build products they need."

GOING PRIVATE

Arrival is also working on partnering with Uber on an affordable, purpose-built EV for ride-hailing drivers.

"We have a non-exclusive agreement with Uber to design the perfect vehicle for the ride-hail market but we need to examine the business model. Do we just put it on the private market or do we take a more sophisticated approach to leasing?" he asks. "I'm looking at what we could actually develop ourselves from the products that we make. We have the materials and the business is working on integrated systems for vehicle servicing."

These fundamental elements are needed, as well as experts in digital technology. "There are very sophisticated human-machine interfaces in these vehicles, which have almost become devices on wheels," says Hurwitz. "We need to embrace that and look at how we can integrate factors such as predictive maintenance for more efficient servicing."

POWER OF TWO WHEELS

Society cannot ignore new modes of transport, such as electric scooters, which have gained popularity – and, to an extent, notoriety – almost overnight. "There are two questions about electric scooters: are they safe? And do they help a city? They're still pretty novel and the data I've seen is that there's just not enough kilometres on the clock to know whether they are safe or more dangerous than bicycles. However, there's a lot of vulnerable road users who are worried about them," says Hurwitz.

As for whether they help cities or not, Hurwitz thinks, again, that the jury is out: "Some people really love them. For those who don't want to ride a bike – for whatever reason – it's the easiest convenience. They also encourage people to choose an alternative to driving or travelling by car. Then again, they may discourage some from walking or taking the bus.

"But they're here and everything that's invented cannot be uninvented," he reasons. "So we need to grasp the technology and see if it can be turned into something to help cities."

AUTONOMOUS OPERATIONS

The shift to driverless vehicles might be some way off but Hurwitz's business is prepared: "We've talked about Arrival being 'autonomous-ready'. The biggest barrier is going to be regulation. I know, having been that person, that somebody in the regulations office will eventually need to say: 'I hereby decree that this is safe enough'. That's really hard to do. It's not just about morals and ethics, it's about technical capability.

"The technology is maybe 98 per cent ready. But people are realising that the last two per cent is extremely hard to get right," he says. "The important point is that human brains have had millions of years of evolution to be able to sense, manage and deal with uncertainty and complexity and then react. The AI algorithms are extraordinarily powerful – mind-bendingly so. But if you add in pedestrians, other vehicles and unpredictable situations, it's really very hard to navigate!"

The continuing shift to electric means delivery drivers can reduce their impact on the cities they're operating in

IN BRIEF: THE ARRIVAL STORY

- Founded 2015.
- Headquartered in the UK and USA with offices in Germany, Netherlands, Israel, Russia and Luxemburg.
- More than 2,100 full-time employees including around 1,600 engineers of whom 1,100 are software engineers.
- Four microfactories undergoing fit-out in South Carolina, US; Bicester, UK; and Madrid, Spain. Recently announced research and development facility in India.
- Signed contracts with total order value over $1.2 billion, including a commitment by United Parcel Service to purchase 10,000 vehicles from Arrival in the US and Europe.
- Four vehicles expected to market by 2023 with the Arrival Van going into public trials later in 2021.

THIS MUCH I KNOW... JOANNA ROWE

Production manager, High Performance Engine Assembly Facility, Ricardo Performance Products – and one of *Autocar*'s Great Women: Rising Stars 2021

It was a little overwhelming to be named as one of *Autocar*'s Great Women. It's very flattering, obviously, when your progress is recognised by such a prominent award. It acknowledges all the hard work that's been put in over the years and shows that I am on the right road.

Engineering is sometimes seen as a 'dirty hands' job, more for men than women. I would say come and look at our engine assembly line because it's not that dirty – it's clean and bright. For sure there are some areas of manufacturing where you need to roll your sleeves up, but if I can do it so can anyone. We already have a female quality engineer, compliance engineer and supplier quality engineer within the department and we definitely want to encourage more women to take up engineering and manufacturing roles both within my section and across Ricardo.

We must encourage greater diversity within engineering and STEM subjects as a whole. There's a lot to be said for visibility like the *Autocar* magazine and website awards while Ricardo has been running STEM events for some time. Even at primary school age we invite children in to see the operation and we've held 'Bring your daughter to work' days so girls can see first-hand what an engineering environment is like and meet the women working here. I think there has been a stigma attached to going down an apprenticeship route versus academia, in that it may be perceived not to carry the same status as a university degree does.

It's important for me to help shape Ricardo's diversity and inclusivity programme. Media interviews are good exposure to show that someone like me can achieve a senior role in engineering, but I also sit on Ricardo's Global Diversity, Equity and Inclusivity (DEI) Council. We're a group from across all Ricardo's divisions in the UK, Europe, USA and China meeting monthly to discuss how we can advise the board on DEI topics. As a result more people are now engaging with our 'Respect' channel and we've recently been involved in World Pride Month.

"YOU HAVE TO STRIVE FOR PERFECTION WHEN YOU'RE BUILDING ENGINES FOR MCLAREN"

The purely academic route doesn't suit everyone, especially on the manufacturing side, so a combination of hands-on skills with technical knowledge should be encouraged by schools. We're beginning to see a shift in attitude with quite a few apprentices coming through; young people are increasingly savvy and understand that they can earn a good salary while taking an apprenticeship rather than going to university and studying a STEM subject.

Since joining Ricardo five years ago, I've played a lead role in introducing the brand new engine launched in the McLaren Artura supercar to our production facility at the Shoreham Technical Centre. We have a team of 50 people operating over two shifts to produce 100 supercar engines per week to hugely demanding quality standards. Restructuring last year as a result of COVID-19 gave us an opportunity to re-set and recognise that we can still improve further. You have to strive for perfection when you're building engines for McLaren.

A day in the life...

GEMMA COX

Student and Ricardo Engineering Prize winner

GEMMA IN BRIEF

Title: MEng Mechanical Engineering student, University of Warwick
Honours: Ricardo Engineering Prize for the most promising female engineering student

The team carried out work in a COVID-safe manner, where if required social distancing was broken for short durations

I've just completed my work placement with Ricardo, which was part of the Ricardo Engineering Prize. It has been great to take that first step on my professional engineering career before I go back to university to complete my Masters degree.

During the placement I had the opportunity to carry out and present market and technical research into solid oxide fuel cell technology which has great potential to reduce the carbon footprint in marine and large stationary applications. The research I did gave me a better sense of the marketplace and of just how many companies are out there delivering and developing new and exciting technologies for the global movement to cleaner power.

I was also able to learn to use an industry standard CAD software, CATIA, for a project to design and optimise inverter packaging in transmissions. Developing my skills on another CAD software has been of real practical benefit for my future career prospects. Working with the technical requirements and design brief for a real-life project was great experience and has furthered my understanding of the process involved in such work.

I don't come from an engineering family but I have always enjoyed making things and helped dad with DIY when I was younger. I particularly liked constructing three-dimensional models and structures in design classes at school; that, together with going on a week-long course run by the Engineering Development Trust, helped me figure out what I wanted to study at university.

My advanced mechanical engineering design module at Warwick involved modifying performance motorbikes. My team had to take a single cylinder 50cc engine block and modify it into a multi-cylinder engine block. We had to model our new design in Fusion 360 CAD software and carry out simulations and analysis.

For my third-year project, I chose a design brief in partnership with The Midland Air Museum. I produced an interactive display of the internals of a W1 Whittle jet engine. Sir Frank Whittle was the pioneer of the jet engine and it's incredible that he triggered the whole progression to the technology we are still using today.

At university I've been a member of the Warwick Moto student team that has designed, built and raced an electric superbike. It's interesting to focus on the electrification of motorcycles because it feels like the industry has perhaps been a bit slower to move to electrification.

I've also co-founded a couple of businesses, one of which, Ardenti Engineering, is with a talented friend of mine who has strong CAD skills. We have brought together the engineering knowledge from our degrees plus my business experience to offer CAD design services at low cost.

"ENGINEERING IS INCREDIBLY BROAD, AND SO IS THE RANGE OF OPTIONS AND OPPORTUNITIES OFFERED BY THE RICARDO GROUP"

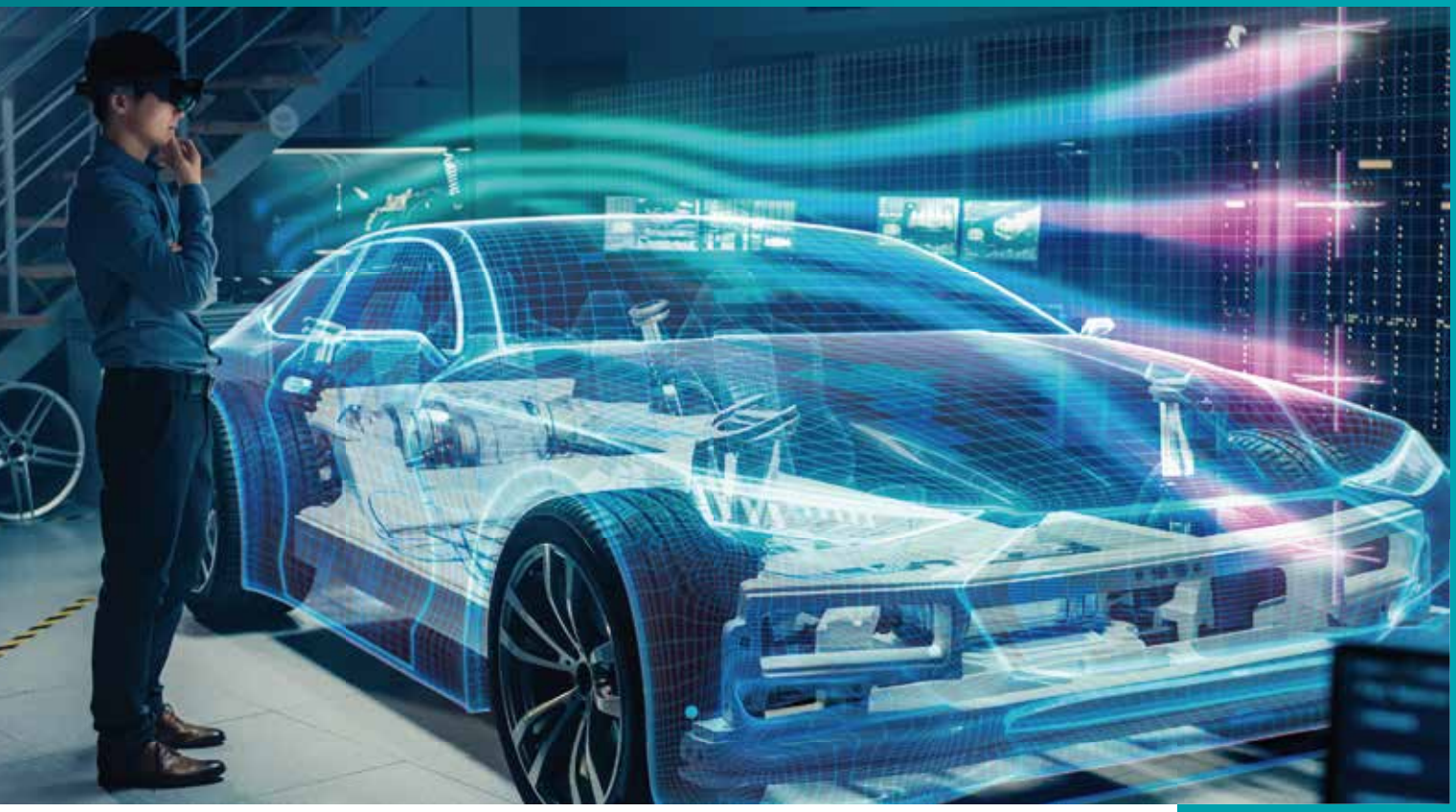
All these projects have taught me that creativity is vital in engineering. My interest in designing and making clothes has a lot in common with engineering processes because you often need to come up with novel solutions for unexpected problems. It's important also to understand how to manage costs in production – for example, adding a tiny extra colour to a T-shirt design can make a huge difference to the cost and hugely complicate the manufacturing process.

Engineering is incredibly broad, and so is the range of options and opportunities offered by the Ricardo group. No two projects are the same and I've relished the chance to see different technologies in action and understand how the various engineering disciplines interact with each other. RQ

As well as the Ricardo Engineering Prize, the company offers a wide range of full-time apprenticeship and graduate opportunities: careers.ricardo.com

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.

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