

Ricardo Quarterly Review

Summer 2022

RQ

A focus on the latest in innovation,
sustainability and technology



Small islands

Facing up to the challenges of
energy transition

Houses imperfect

Why domestic
decarbonisation should
be on everyone's agenda

Carving out a niche

Meeting the demand for
bespoke battery solutions



Critical thinking about **critical infrastructure**

Building a more resilient future



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RQ NEWS

Latest developments from around the global Ricardo organisation



Ricardo supporting Greater Toronto rail transformation

Independent safety assessments during the GO Expansion upgrade design stage

Ricardo Certification has been appointed as the Independent Safety Assessor (ISA) for the forthcoming transformation of rail transit across the Greater Toronto and Hamilton Area (GTHA) in Ontario, Canada.

As the ISA, Ricardo will provide independent scrutiny of the programme's safety documentation during its design phase to ensure it fully complies with relevant standards. Carrying out these assessments at this early stage will reduce the risk of delays or costly rectification works during the later construction, installation and testing phases.

The role was awarded by Metrolinx, a crown agency of the government of Ontario that is responsible for GO Transit, the regional rail and bus network in the GTHA.

"This is a complex, multi-faceted programme of works," says Richard Gibney, Certification Director for Ricardo

Certification, "with new rolling stock, a new traction system and extensive infrastructure upgrades which must be designed to the highest safety standards.

"Using our experience of similar projects around the world, we will provide independent assessment to help ensure safety remains at the forefront throughout the key design stages."

GO Transit's rail network consists of seven lines operating out of Toronto's Union Station, served by an ageing fleet powered by diesel locomotives. Infrastructure limitations have imposed a variable timetable across the network, with traffic oriented towards peak rush hour periods. However, passenger numbers on GO Transit are steadily rising: in 2020 the network carried more than 57 million passengers.

The GO Expansion upgrade will deliver a faster and more frequent service using

Toronto will benefit from a faster and more frequent rail service

modern electric-powered rolling stock. The programme also includes new track, signalling and more than 650 kilometres of electrification. The result will be a significant increase in services from 3,500 trains per week in 2019 to more than 10,000, with services operating at least every 15 minutes. The new fleet is also forecast to deliver a 50 per cent reduction in operating costs per kilometre.

As the appointed ISA, Ricardo teams will support the programme throughout the design phase to assess whether Metrolinx and ONxpress Transportation Partners have developed relevant safety documentation, including the system definition, system safety plan and safety case. This must fully comply with standards such as the Canadian Method for Risk Evaluation and Assessment and EN50126, the international standard for the specification and demonstration of Reliability, Availability, Maintainability and Safety for railway applications.

Recognition as 'Excellent Supplier'

Ricardo received an Excellent Supplier Performance Award at Toyota Motor North America's 2022 Annual Supplier Business Meeting.

The event recognises top performers among Toyota's North American contractors, distributors and service suppliers. Ricardo received the award for development work on fuel cell integration for heavy duty applications to help decarbonise the global transportation industry.

Ricardo has been working with Toyota to develop Class 8 heavy duty zero emissions fuel cell electric trucks, with the objective of delivering

increased vehicle range, reduced refuelling times and improved vehicle efficiency. The company assisted in the design, testing and development, including systems integration and packaging of fuel cells, power electronics, hydrogen tanks, cooling systems, batteries, electric motors and transmission.

"We value our longstanding partnership and look forward to our continued collaboration to develop new decarbonisation technologies for the global transport sector," says Adrian Schaffer, President, Emerging Mobility.

New software release focuses on reducing tailpipe emissions

The latest release from Ricardo Software is now available for download. The 2022.1 release joins other leading-edge tools and solutions to facilitate design and optimisation, whether for the internal combustion engine (ICE) with new fuels, hybridisation, full electrification or fuel cell technology. The release focuses on reducing tailpipe emissions and features a number of key enhancements:

- **Fluid dynamics:** the drive to design better, more environmentally friendly engines places increasing emphasis on fast calibration of real-time models with accurate predictive combustion models. This release builds on the powerful real-time tuner delivered in 2021.3 to enable running the tuner on

High-Performance Computing clusters, to deliver real-time engine plant models quickly within a virtual product development workflow.

- **Structural mechanics:** original equipment manufacturers are challenged to decrease the carbon footprint of the ICE, reducing not only its friction and oil consumption but also its cost. This requires a toolset which delivers optimal designs. This release makes possible identification of problems to ring pack dynamics that may only occur during a transient, allowing the engineer to reduce oil consumption and tailpipe emissions.
- **Complex systems:** manufacturers are under increasing pressure to reduce tailpipe emissions produced by ICE powertrains. Building on the company's expertise in emission after-treatment modelling, Ricardo Software is now able to announce an exhaust after-treatment library that allows reduced tailpipe emission tailpipe emissions using detailed 1-D predictive models.

Visit bit.ly/softwarerelease to find out more and download 2022.1.



Full speed ahead for Aston Martin

Ricardo will be supplying the advanced transmission for Aston Martin's Valkyrie Spider hypercar.

This follows successful supply of the transmission for the highly acclaimed coupe variant of the Valkyrie. It builds on Ricardo's proven track record in motorsport together with experience in delivering to original equipment manufacturers in the highly regulated global automotive sector.

Originally designed by Ricardo, the complex seven-speed automated manual transmission is needed to support both road and track use. The challenges posed by combining these two differing environments was a key factor in Aston Martin's decision to engage Ricardo to design, develop, manufacture and test both the transmission system and the associated control software.

Manufacture and assembly of the transmission will take place at Ricardo's Midlands Technical Centre, where marques including Bugatti and Porsche are also supported with world-leading transmission supply.



Support for European Commission's environmental legislation proposals

Ricardo experts play key role in proposed revisions

The Industrial Emissions Directive (IED) controls the environmental impacts of the largest industrial installations across the EU. Ricardo's specialists worked with the European Commission to provide the research to support these proposals, continuing work undertaken in 2020 to evaluate the IED.

"The revisions to the IED address not only the zero pollution agenda," says Tim Scarbrough, Business Area Manager for Environmental Policy at Ricardo, "but also touch on sustainable chemicals, the circular economy, waste and sustainable products, nature and biodiversity, climate and energy, and innovation.

"Our work, in collaboration with partners, assessed in detail the economic, environmental and social impacts of 43 policy measures. It was made all the more robust by the economic analysis underpinning the assessment which adhered to the Better Regulation Guidelines."

Proposals have also been launched for revisions to the regulation controlling ozone-depleting substances and the regulation limiting fluorinated gases. Ricardo's environmental policy and economics team played its part in developing the evidence base underpinning these revisions through studies supporting the Commission's impact assessments.

"The specific proposals for these amendments to the two regulations will help to achieve further emissions savings through restricting specific uses and products," explains David Birchby, Economist and Associate Director at Ricardo. "This will increase alignment with the Montreal Protocol on Substances that Deplete the Ozone Layer, as well as work towards more effective prevention of illegal activities."

According to Sujith Kollamthodi, Director of Ricardo's Policy, Strategy and Economics Practice, "This raft of proposals under the Green Deal continues to push forward the important European agendas of decarbonisation, addressing air quality and transition to a circular economy. It cements Ricardo's role as a leader in providing policy support to the European Commission, picking up where our support for the Fit for 55 proposals in summer 2021 left off."

Nutrient budget calculators to benefit housing developers

Tools created by Ricardo for Natural England

Ricardo has created more than 25 nutrient budget calculators for Natural England, the UK Government's adviser for the natural environment, to allow developers to quantify the nutrient loading that new residential development will add to a site. This will determine the amount of mitigation required to prove nutrient neutrality – the outcome achieved when a particular land use or development within catchment areas of vulnerable watercourses does not result in an increase in phosphate and nitrate levels beyond those currently.

Since a legal case in 2018 which set higher standards for developers to help protect the environment, and advice from Natural England to local planning authorities, the issue of nutrient neutrality has brought house building to a standstill in some areas.

Earlier this year, nutrient neutrality advice was issued to planning authorities in 20 areas in addition to the seven

originally affected, making the release of the calculators especially timely.

"The first step for home builders struggling to get approval for their developments is to calculate the amount of nutrients they may need to offset in order to achieve nutrient neutrality," explains Gabriel Connor-Streich, a Principal Consultant with Ricardo.

The calculators quickly identify the level of nutrient mitigation needed to ensure residential development doesn't impact valuable protected ecosystems.

"The next step is to help support developers expand their understanding of how different mitigation solutions can best provide beneficial impacts on protected habitats," adds Connor-Streich. "This is the aim of our follow-up work for Natural England."

Nutrient budget calculators will help protect valuable ecosystems



Repowered and ready

Hydrogen fuel cell bus on the road

Ricardo has repowered a diesel double-decker bus with a hydrogen fuel cell propulsion system. The project, in partnership with Stagecoach North East, was part funded by the Department of Transport through its Hydrogen Transport Hub Demonstration competition and featured in the Winter 2021 edition of RQ. The result is a zero-emissions demonstrator ready for a ten-week test and demonstration programme around the Tees Valley and Brighton and Hove.

The bus deploys a hydrogen fuel cell system that produces zero emissions when using green hydrogen. While battery electric buses offer the right zero-emission solution in many cases, their shorter range, longer charge times and dependency on grid infrastructure mean that a mixed fleet of battery electric and hydrogen fuel cell buses will be required to achieve decarbonisation goals.

Ricardo is seeking to offer the hydrogen fuel cell re-powered vehicles at around half the price of a new bus, significantly reducing the upfront investment required while

also avoiding some 45,000 kilograms of carbon dioxide emissions by extending the life of existing buses rather than building from new.

The aim is to secure 50 per cent match funding investment plus customer commitment for an initial production of 150 buses that can enter service from late 2024.

"There are around 38,000 buses in service in the UK," says Andrew Ennever, Ricardo's Service Leader for hydrogen fuel cells. "We're excited by the opportunities this type of project provides to work with operators in support of their future environmental strategies."

"The project has drawn on the breadth and depth of Ricardo's capabilities, from complex control systems to thermal systems, mechanical design to vehicle integration. We are now capturing learnings from the demonstration trials to include further refinements in a future production solution and other hydrogen fuel cell vehicle applications."

The Ricardo team with the hydrogen fuel cell re-powered bus that could significantly reduce upfront investment and avoid 45,000 kilograms of carbon dioxide emissions



Why greater efficiency is the fastest and most direct way to increase our energy security

Richard Scotney, Global Energy Efficiency Lead, World Wildlife Foundation



Richard Scotney leads WWF's energy efficiency work. He is based in Phnom Penh, Cambodia. WWF's mission is to stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature. With teams in over 80 countries, WWF works to tackle the global climate crisis through promoting renewable energy and increasing energy efficiency.

The war in Ukraine is changing the energy policy landscape. Governments are reacting fast to reduce their dependence on Russian fossil oil, coal and gas. However, WWF offices globally are witnessing fossil fuel lobbyists pushing for increased investment in gas and oil production and infrastructure. This would be devastating for the planet and throw out the possibility of restricting global warming to less than 1.5°C.

Energy efficiency and conservation is one of the most impactful ways to respond to the energy crisis. The recent Intergovernmental Panel on Climate Change report, 'Climate Change 2022: Mitigation of Climate Change', showed that measures to reduce energy demand can cut global greenhouse gas emissions by 40-70 per cent. Yet at the moment, we are not on track on our energy efficiency goals. To achieve net zero emissions by 2050, we need four per cent annual advances in energy efficiency. Between 2015 and 2020 the world only achieved 1.3 per cent.

In terms of speed, energy efficiency cannot be beaten. New oil and gas will take 30 years to bring online [by which time the world should not be investing in new fossil fuels anyway!]. Nuclear and hydropower typically require over 20 years to establish. Solar is quick but still can take at least two years. But energy efficiency can start immediately:



THE WAR IN UKRAINE IS CHANGING THE ENERGY POLICY LANDSCAPE. GOVERNMENTS ARE REACTING FAST TO REDUCE THEIR DEPENDENCE ON RUSSIAN FOSSIL OIL, COAL AND GAS



Reducing heating demand in homes through energy efficiency and switching to renewable heat solutions. Households account for 46 per cent of Europe's fossil gas use and have significant reduction

potential.


Reducing industrial energy demand, particularly for heating: industry has become used to low gas prices which has slowed development of alternative solutions. High prices for gas mean firms need to consider renewable heat solutions, particularly solar thermal, and switching to electrification. Indeed, it is estimated that through energy efficiency and electrifying low- and medium-temperature heat processes we can achieve 223 terawatt-hours of savings, equivalent to powering eight million homes. In addition, increasing the EU emissions trading reduction target from 61 per cent to 70 per cent will further drive efficiency.

Reducing electricity demand, particularly for air conditioning: in response to the Ukraine crisis, Italian Prime Minister Mario Draghi posed the dramatic question: 'Do you want air conditioning or peace?' and in many hot countries air conditioning is the main driver of electricity consumption. Italy has mandated that air conditioning be set at no lower than 25°C, in line with campaigns in Japan and China.

Reducing demand in transport: beyond gas, several countries are looking to reduce oil demand from transport. In the short term, working from home, reducing speed limits and public information campaigns to encourage a shift to public transport and cycling can instantly reduce gas use.

WWF offices are responding to this crisis by making the case for energy efficiency efforts.

WWF Germany has published a series of recommendations for its country's government and society. According to Voahirana Randriambola of WWF Madagascar: "The best way forward is to accelerate the country's energy independence by optimising our consumption systems and exploiting local renewable energy resources." In India, WWF's Nitin Kaushal says Indians "need to think around the country's self-sufficiency and demand management in energy and fuel". Throughout the WWF network, we are committed to preserving nature and our offices are working to ensure the right decisions are made to address the energy crisis.

"There are basically two possible responses to the crisis," adds Sergio Bonati of WWF Spain: "1. Producing more fossil fuels and/or sourcing it from different regions, which means higher investments and longer dependency on fossil fuels; or 2. Accelerating the deployment of renewable energies and energy efficiency with urgent measures, worldwide collaboration and increased funding. Our choice is clear: we must ensure that governments choose option 2." 



Certified for operation

London's Elizabeth Line opened to passengers in May, concluding one of the largest and most complex assessments ever performed by Ricardo Certification.

As the appointed Approved Body (ApBo) for the construction of the central tunnelled section under the heart of the capital, Ricardo's experts received more than 6,000 evidence submissions – including design drawings, safety cases and hazard records – which were assessed against an extensive range of technical specifications. These assessments gave confidence to stakeholders that all legal requirements were being met as construction progressed.

In addition to the ApBo role, Ricardo was also the central section's appointed Designated Body (DeBo) to assess compliance with the UK's National Technical Rules, and Assessment Body (AsBo) for both Crossrail and Rail for London Infrastructure, the infrastructure manager of the central section.

“WE SUPPORTED THE ELIZABETH LINE FROM DETAILED DESIGN TO THE LAUNCH OF PASSENGER SERVICES”

As the AsBo, it was Ricardo's responsibility to determine whether procedures for managing hazards and evaluating risk were compliant with the Common Safety Method on Risk Evaluation and Assessment Regulation, a mandatory requirement for major rail projects.

Almost four decades elapsed between the first official proposals for an east-west Crossrail line under London and the start of construction in 2009. The actual work above and below ground took a comparatively short 13 years.

“We supported the Elizabeth Line from detailed design to the launch of passenger services,” says Simon Whitehouse, Ricardo's UK Certification Director. “By joining the programme at such an early stage, we brought consistency to evidence assessment while building an extensive knowledge base of the core infrastructure.”

“This meant we could complete a complex approvals process as efficiently as possible, ensuring the UK regulator was satisfied that more than 1,400 specified technical requirements had been met.”

A valuable legacy from this assignment lies in the way future mainline railway programmes in the UK, such as HS2, will benefit from Crossrail's experiences. Technical standards are now more honed towards the practicalities of the rail environment while workshops hosted by Ricardo for Crossrail and its supply chain have brought greater understanding of the new regulatory landscape and its implications.

Crossrail has also highlighted opportunities to bring greater efficiency to future assurance processes. As the single ApBo, DeBo and AsBo provider, Ricardo accumulated a detailed knowledge bank of the railway and its sub-systems, providing continuity as suppliers joined and left the programme.

The result of this extraordinary feat of engineering is an underground train service whose speed, comfort and accessibility will transform the experience of passengers for decades to come. 



DISRUPTION AHEAD

Critical thinking about critical infrastructure



Infrastructure is the backbone of a modern, interconnected economy. **Tim Curtis** explains how disruption to key systems can cause substantial economic and social damage – and how opportunities can emerge from almost every challenge



From the impact of extreme weather events to the urgency of climate change targets, there is greater pressure than ever on the strategic resilience of existing critical infrastructure and the development of new assets.

On the one hand, systems such as power, water and transport – especially those that are old or poorly maintained – are increasingly vulnerable to damage or disruption. On the other, the need to decarbonise provides a challenging context for organisations engaged in large-scale infrastructure projects.

Many existing systems are organised in complex networks, sometimes spreading across national borders and even continents. They are under pressure from population growth, accelerating urbanisation, conflict and fragmented governance:

- More than 470 million people living in cities around the world, are expected to face extremely high water stress by 2030.
- The COVID-19 pandemic has underlined the need for countries to build greater resilience into their infrastructure to ensure the continued operation of critical networks in times of crisis.
- The war in Ukraine has severely disrupted the geopolitics of energy, driving oil and gas prices to their highest levels in a decade and forcing many countries to reconsider their energy supplies.
- Some sectors, including shipping, chemicals, cement and steel-making, are notoriously difficult to decarbonise.
- There are challenges in reducing the upfront and operational cost of low-carbon investments while unlocking innovation.
- Although clean energy and infrastructure have countless benefits, some decarbonisation pathways risk negative


“Society depends on safe, sustainable and resilient infrastructure. Future generations will hold us to account if we fail to deliver it”

impacts among certain communities, such as the exploitation of children in cobalt mining for use in electric vehicle batteries.

As the articles in this issue of *RQ* show, infrastructure challenges also bring opportunity. In London, Ricardo undertook one of its largest ever assessment programmes while building an extensive knowledge base of the core infrastructure of the Elizabeth Line.

Across the UK, our experts have developed a net zero 2030 roadmap for the water industry.

And in remote locations around the globe, our teams are helping island states improve their own energy security by developing greater renewable capacity.

Society depends on safe, sustainable and resilient infrastructure. Future generations will hold us to account if we fail to deliver it. 

To find out more about Ricardo's infrastructure planning and advisory services visit: ee.ricardo.com/infrastructure-advisory.

Tim Curtis is Managing Director, Ricardo Energy & Environment



ENERGY CHALLENGES

Small islands, BIG IMPACTS

Islands face many unique challenges. They are also at the forefront of climate action and sustainable development initiatives. **Thomas Amram** and **Maria Nieto** look at how, with Ricardo's support, islands around the world are facing up to the challenges of energy transition and building a more resilient future.

Geography, history and infrastructure pose very specific issues for islands around the world. According to the open-access data portal the Metabolism of Islands (Mol)¹, most suffer from tenuous resource supply and security, reduced capacity to absorb waste and limited means to develop economies of scale. Collectively they account for less than one per cent of the world's gross domestic product while their size, remoteness, international debt, out-migration, undiversified exports and dependency on imports to meet basic needs all create vulnerabilities.

Sustainable Island States (SIS) are particularly susceptible to the impacts of climate change and it is imperative that they lead the way in decarbonisation efforts.

Increases in global mean temperature correlate to rises in sea level – and it's expected that the sea level could rise up to one metre between now and 2100 under business-as-usual projections. This would have a dramatic effect on the wellbeing of citizens and national economies in SIS. According to the United Nations Framework Convention on Climate Change, such a rise could swamp 1,300 square kilometres of land, flood 80 per cent of port land and damage or make unusable 28 per cent of airports across Caribbean islands alone by the end of this century.

Tropical storms and hurricanes also correlate with climate change and the warming of the oceans. Both the frequency and magnitude of tropical

storms and hurricane events have increased substantially over the last century and SIS face heightened exposure to such extreme weather events.

Many SIS have historically been dependent on imported fossil fuels for power generation. However, reliance on imports makes power supply vulnerable to interruptions, whether from geopolitical instability or logistical issues, and exposes customers to price volatility.

The total environmental impact of fuel imports has also been increasing due to the growth of high-risk extraction methods such as fracking. Transitioning to clean local power generation can provide SIS with improved energy security and independence, as well as helping to combat climate change and environmental impacts.

Breaking free from short-term thinking

SIS generally have small power sectors and many rely on generation from one vertically integrated utility with minimal generation derived from Independent Power Producers (IPPs).

The importance of the tourism industry and limited land mass can also constrain opportunities for developing new utility-scale power projects. A luxury hotel complex, for example, may not want an offshore wind farm in direct sight of their most expensive rooms.

Also many SIS do not yet have robust regulatory frameworks in place, which can create uncertainty for utilities, IPPs

and investors. These factors all diminish the attractiveness for private sector participation in the power sector.

Furthermore, the power sector in many SIS lacks adequate staff numbers or those with specialised knowledge and skills in power planning.

These limitations mean that power sector planning may only be focused on short-term generation and responding to urgent needs. This has very real and practical consequences. For example, short timescales can exclude competitive procurement, projects using new technologies or those requiring more time for development. In some instances, short-termism has led to ad hoc or rushed licensing of unsolicited IPP projects with limited consideration for an SIS's actual long-term requirements.

An emphasis on short-term cost and benefits can also exclude consideration of many renewable energy projects due to higher upfront costs, despite the fact these projects offer significant benefits. Long-term planning is likely to bring more sustainable power sector development and provide long-term benefits to customers.

Creating a cleaner, greener future

Many islands are becoming hubs for innovation that are leading the way in adapting to climate change, building resilience and accelerating their sustainable development.

A 2021 report by the International Renewable Energy Agency (IRENA)²

→ showed that Small Island Developing States (SIDS; see panel) had achieved double the global figure for growth of installed renewable energy capacity since 2017. And while 90 per cent of transport on SIDS is dependent on fossil fuels, 85 per cent of SIDS had included renewable energy targets in their climate pledges as part of the 2015 Paris Agreement compared to 70 per cent of all nations.

Examples include Antigua and Barbuda, where an electric mobility roadmap is aiming for 100 per cent ecological transport by 2030.

In Seychelles, where 90 per cent of energy needs are met from imported oil, the Seychelles Energy Commission has begun to address the issue with solar panels installed on all schools on the country's three main islands.

And on Rapa Nui in the south-eastern Pacific, which had been on the brink of environmental collapse after decades of indiscriminate tree felling, illegal fishing, poor waste management and reliance on diesel, the world's most remote solar photovoltaic plant is now supplying clean energy to 7,000 inhabitants.

Ricardo's international experts work with SIS across the world to develop sustainable systems that improve energy security, independence and resilience, bring cost reductions for businesses and consumers, support local economic development and combat climate change and negative environmental impacts.. 

Thomas Amram (Head of Planning and Regulation) and Maria Nieto (Consultant) are part of Ricardo Energy & Environment's Power Planning and Solutions team.

Supporting Bermuda's integrated resource plan

The power sector in Bermuda has faced fundamental challenges. First, end-user rates are very high, at approximately 40 US cents per kilowatt-hour, of which about 35 per cent comes from the cost of fuel. Second, Bermuda is experiencing a population decline which, combined with efficiency gains, means fixed costs related to the supply of power need to be recovered from decreasing sales volumes. Third, 96 per cent of the 100 megawatts (MW) of electricity supplied to customers comes from thermal generators.

Approximately 70 MW of capacity was retired in 2020 due to ageing and a further 70 MW is expected to be retired by 2040, while energy demand is likely to remain relatively stable over the same period. To address these challenges, in 2019 the Regulatory Authority of Bermuda commissioned Bermuda's first Integrated Resource Plan (IRP), which Ricardo supported.

Ricardo's experts collated the underpinning data, including feedback from a public consultation which had been critical of the lack of emphasis on renewable energy; benchmarked suitable technologies; and modelled the cost of future energy scenarios, including carbon emissions.

Over the next five to 10 years, the island is due to add 21 MW of utility-scale solar photovoltaic, 60 MW of offshore wind power and significant amounts of distributed generation such as residential and small-scale solar. The IRP enabled the island's authority to select the energy mix that would best meet consumer- and climate-focused needs over the next 20 years.

As part of its Economic Recovery Plan, Bermuda has also created an energy regulatory sandbox to encourage renewable energy technology developers to test their products. This will facilitate emerging clean energy solutions, such as wave energy; encourage much-needed inward investment; and encourage companies serious about pursuing innovative technologies in the energy sector to come to the island.

Many islands are becoming hubs for innovation that are leading the way in adapting to climate change, building resilience and accelerating their sustainable development

Achieving maritime decarbonisation on the Orkney Islands

Ricardo is part of the £2.2 million HIMET (Hydrogen in an Integrated Maritime Energy Transition) project to explore solutions for decarbonising ferries as well as shore-side activities in ports.

HIMET centres on the decarbonisation of ferry services and cruise terminal operations, drawing on local energy system and maritime expertise in Orkney and leading technology developers and sector experts from across the UK.

Ricardo's role is to design and develop the combustion system and engine hardware to convert an existing natural gas engine to 100 per cent hydrogen operation. The replacement of a marine diesel engine with a hydrogen version is a promising pathway to provide both new and retrofitted vessels with zero-emission propulsion.

HIMET will also carry out research and stakeholder engagement to explore how decarbonised fuels (hydrogen and ammonia) coupled with technology innovations can support broader maritime energy transition, help overcome regulatory barriers and showcase the maritime working practices of the future.

Moving towards 100 per cent renewables on Barbados

A delegation from the Government of Barbados visited the Orkney Islands to learn how Scotland has become an international leader in marine renewable energy and has delivered more than 100 per cent of its electricity demand from renewables.

The delegation toured Scotland's leading wave and tidal energy open sea test facilities and met members of the Sustainable Islands International programme, which is managed by Ricardo on behalf of Scottish Enterprise, Highlands & Islands Enterprise and Scottish Development International.

Ricardo managed Barbados's integrated resource plan which seeks transition to 100 per cent renewable energy by 2030.

Long-term strategies for Dominican Republic and Antigua

The 2015 Paris Agreement requested each country to outline its post-2020 climate actions, known as a Nationally Determined Contribution (NDC). This is a chance for a country to translate its climate goals into the policies, financial commitments and measures to reduce emissions and enhance climate resilience.

NDCs are non-binding but set within a binding framework designed to ratchet up climate action over time and are expected to be updated on a five-year cycle. Ricardo has supported both Dominican Republic and Antigua with implementation of their NDCs and long-term low-emission strategies.

Shetland Islands transitioning to zero-carbon fuels

Ricardo is a key member of a £500,000 project to support the transition to zero-carbon fuels for the Shetland Islands' maritime industry.

The 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, which aligns with the archipelago's 2030 net-zero target. The Shetland Islands' maritime industry's carbon dioxide emissions currently total around 300 kilotonnes per year.

Ricardo is developing a 'digital twin' of representative marine vessels and the port energy infrastructure within the island energy system to facilitate testing of different scenarios, energy flows and emissions impacts.

Researchers will determine which zero-carbon technologies the different vessels could switch to and input the twin models into a digital dashboard which will monitor the flow of renewable fuels from 'well to wake'. The results of the study will help assess the impact of zero-carbon fuel supply in terms of storage space needed, the annual amount of renewable electricity required and other factors, such as land and water, required to match the digital model.

SMALL ISLAND DEVELOPING STATES

Small Island Developing States (SIDS) are a distinct group of 38 United Nations (UN) member states and 20 non-UN members/associate members of UN regional commissions.

SIDS are located in three geographical regions: the Caribbean, the Pacific, and the Atlantic, Indian Ocean and South China Sea. The aggregate population of all SIDS is 65 million, slightly less than one per cent of the world's total. Each island's Exclusive Economic Zone – an area of the sea prescribed by the United Nations Convention on the Law of the Sea in which a sovereign state has special rights regarding the exploration and use of marine resources, including energy production from water and wind – is, on average, 28 times its land mass.

These 58 SIDS – from Jamaica and Barbados to Samoa and Tonga – were formalised at the 1992 UN Conference on Environment and Development. This was in recognition of their small population size, remoteness from international markets, high transportation costs, vulnerability to external economic shocks and fragile land and marine ecosystems, all of which leave them particularly vulnerable to loss of biodiversity and climate change.

Caribbean islands are increasingly vulnerable to climate impacts

To find out more about Ricardo's support for sustainable development in island states, visit ee.ricardo.com/energy/sustainable-islands

*metabolismofislands.org
*irena.org/DigitalArticles/2021/Jan/SIDS

! UNDER PRESSURE

WATER

– a deep dive

Water is our most precious resource. Its infrastructure is critical for every aspect of life while water-related investments are a major element of countries' capital assets. In this special feature, *RQ* looks at some of the global challenges and opportunities around the supply, treatment, storage and transportation of H₂O.

WHY HYDRO-POLITICS WILL SHAPE OUR FUTURE

In 1995 Dr Ismail Serageldin, the founding director of Bibliotheca Alexandria in Egypt and then vice-president of the World Bank, made a dramatic prediction: "If the wars of the 20th century were fought over oil," he declared, "the wars of the 21st century will be fought over water – unless we change our approach to managing this precious and vital resource."

At the time of Serageldin's statement, tensions due to major upstream dam construction and extraction on the Nile threatened the water security of millions of people. Since then, pollution, flooding, drought, conflict, population growth and lifestyle demands have contributed to a situation where, by 2030, 47 per cent of the world's population will be living in areas of high water stress.

This may seem extraordinary given that water covers 70 per cent of the earth's surface. However, fresh water comprises only three per cent – and two-thirds of that is frozen in glaciers or otherwise unavailable.

Climate change is fundamentally changing patterns of weather and water around the world, with floods in some places and droughts in others. More than half the world's wetlands have disappeared while agriculture is both a heavy consumer and a heavy waster of water through inefficient irrigation.

"In some countries we are seeing legal action against large companies or agricultural concerns that have exploited water abstraction rights previously enjoyed by local communities," says

Helen Gavin, Ricardo's Associate Director for Water. "They are causing groundwater levels to fall and aquifers to become dry. If the word 'war' is too emotive, then 'ignition point' is certainly appropriate."

In the UK, according to the Royal Geographical Society, the average citizen's daily 'water footprint' is 3,500 litres¹. However only 150 litres of that is consumed in the home with the rest hidden in the irrigation, manufacturing, processing and packaging of everyday products, some originating from regions already at risk from drought or water stress.

As Emma Howard Boyd, Chair of the Environment Agency, put it in her foreword to 'Meeting our future water needs: a national framework for water resources', published in 2020: 'If we don't take action many areas of England will face water shortages by 2050. An increasing population, demand from agriculture and industry and improving our resilience to drought will all put significant pressures on our water resources. The climate emergency – periods of hotter and drier weather – will only exacerbate these pressures.'

¹21stcenturychallenges.org/water-security/

"IN SOME COUNTRIES WE ARE SEEING LEGAL ACTION AGAINST LARGE COMPANIES OR AGRICULTURAL CONCERNS THAT HAVE EXPLOITED WATER ABSTRACTION RIGHTS PREVIOUSLY ENJOYED BY LOCAL COMMUNITIES"

HELEN GAVIN, RICARDO ASSOCIATE
DIRECTOR FOR WATER

TESTING THE WATERS – THE GLOBAL CHALLENGES

Increasing urbanisation

"Bigger, denser towns and cities bring problems because of urbanisation," says Ricardo's Helen Gavin. "Urbanisation means more hard, impermeable surfaces which water can't infiltrate, or the water is channelled in such a way that the volume and flow exceed the capacity of receiving watercourses or soakaway. So there's a snowball effect, causing flooding downstream."

"When this happens there is little recharge of local groundwater or water tables. So you have this double whammy effect: more hard surfaces increase the flooding risk and impact and also reduce the ability of the local environment to store water and maintain water levels."

Gavin points to Sustainable Drainage Systems (SuDS) as a way forward: "Sustainable drainage is a move away from the traditional approach of designing only to manage flood risk, where water run-off is regarded as a problem, to surface water being treated as a valuable resource and managed for maximum benefit. In the UK, for instance, any new development needs to be able to capture and store water arising from it so the water can sink into the ground."

SuDS take account of water quantity (flooding), quality (pollution), biodiversity (wildlife and plants) and amenity. They're a suite of components working in different ways: to enable water to soak into the ground, flow into a watercourse, sewer or on-site storage, and to slow down flows. *susdrain* (susdrain.org) is a sustainable drainage systems resource created by the Construction Industry Research and Information Association.

Unsustainable abstraction

"Water isn't valued as much as it should be," says Gavin. "Globally, we suck it out the ground and use it for something that gives economic return, with minimal thought for the effects of over-abstraction or the increased salinisation or desertification of land."

The UK has sought to reduce the number of abstraction licences where there is an environmental impact. Chalk rivers, for example, are our equivalent of the rainforest – an extremely rare habitat supporting immense biodiversity and prized for the high quality of the water. Eighty-five per cent of the world's chalk streams are in England, with 29 per cent in East Anglia. Most water drunk in the east of England comes from rainwater stored in natural chalk aquifers which feed the streams.

"For obvious reasons," Gavin explains, "abstraction has taken place since the 1800s when private water companies started to take water and sell it to customers. However, our chalk rivers now face major challenges as a result of over-abstraction, climate change and population growth."

In 2021, the Catchment Based Approach (CaBA; catchmentbasedapproach.org) – an initiative bringing together Government, local authorities, water companies and businesses – published a chalk stream strategy setting out actions and recommendations on water resources, quality, habitat restoration and management. CaBA is working in all 100-plus river catchments across England and cross-border with Wales to support the Government's '25 Year Environment Plan'.

Published in 2018, the Plan included the ambition to reduce the damaging abstraction of water from rivers and groundwater, with the aim that by 2021 the proportion of water bodies with enough water to support environmental standards increased from 82 per cent to 90 per cent for surface water bodies and from 72 per cent to 77 per cent for groundwater bodies.

Unchecked pollution

This year's monitoring report on the UK Government's '25 Year Environment Plan' found progress 'too slow' and environmental 'tipping points' fast approaching, where gradual decline suddenly becomes catastrophic including collapsed fisheries and dead, polluted rivers.

Gavin highlights the issue of sewer overflows: "Water companies are permitted to overflow partially treated or untreated sewage into waterways when sewage treatment works can't cope with the increased volumes of wastewater now entering the sewer system. This should be a rare event. But it's actually become a frequent occurrence. Sewage overflows and agricultural run-off are the two major sources of pollution for our rivers."

Ricardo is contracted by a number of UK water companies to respond to pollution incidents and also to support the development of Drainage and Wastewater Management Plans (DWMPs). Announced by the UK Government earlier this year, water and sewerage companies must produce 25-year DWMPs looking at current and future capacity; pressures and risks to their networks such as climate change and population growth; and how these challenges will be managed through their business plans in partnership with other risk management authorities or drainage asset owners.

The production of DWMPs will be made statutory through the Environment Act, with companies required to produce draft plans for consultation in 2022 and final plans in 2023.

A number of environmental 'tipping points' are fast approaching for UK waterways



Access to reliable, climate-independent water at stable prices under long-term agreements is critical for South Australian agriculture



HOW RICARDO IS KEEPING THE WATER FLOWING

→ Ricardo has framework agreements with many of the largest UK companies – including Southern Water, United Utilities, Dŵr Cymru/Welsh Water, Yorkshire Water, Thames Water and Bristol Water – to support their long-term planning for sustainable water resources. Ricardo's services include strategic environmental assessments, terrestrial and aquatic ecology surveys, habitats regulations assessments and water framework directive assessments. Here are some of the projects that Ricardo is involved in worldwide.

Severn-Thames Transfer project

Experts from Ricardo's Water practice are supporting one of the strategic water resource schemes to meet supply and demand pressures and bolster drought resilience in south-east England by transferring raw water from the lower catchment of the River Severn to the upper reaches of the Thames. Developed by Thames Water, Severn Trent Water and United Utilities, the scheme could deliver up to 500 million litres of water per day through new interconnectors.

Such an ambitious water transfer project is not unique: a transfer from the Midlands to the south-east using the canal network is being investigated by Severn Trent Water and Affinity Water in partnership with the Canal and Rivers Trust.

Net Zero 2030 Roadmap

Ricardo and Mott MacDonald collaborated to create the Net Zero 2030 Roadmap for trade association Water UK, setting out how the industry must cut its current 10 million tonnes of greenhouse gas emissions. The water industry was the first sector in the UK to commit to net zero carbon emissions by 2030. The roadmap highlights:

- Major investment by the sector in renewable energy generation over the last 30 years, maximising use of biogas and biomethane
- A commitment by water companies to build on a one-third reduction in leakage since the 1990s; triple leakage reduction by 2030; and develop plans to reduce by a fifth the average amount of water used per person by 2050

- A national shift towards refilling water bottles through the Refill campaign. Bottled water is around 900 times more carbon intensive than tap water per litre and generates plastic waste. The industry has helped to increase the number of free refill stations from 1,500 in 2017 to more than 26,000 today. The sector has also committed to preventing the equivalent of four billion plastic bottles ending up as waste by 2030.

Agricultural irrigation in Australia

The Australian consultancy Inside Infrastructure, acquired by Ricardo earlier this year, specialises in water resource management for government and industry bodies, working across strategy, regulation and policy, planning, technical assessment, investment appraisal and asset management.

Recent contracts include delivery of the business case for the Northern Adelaide Irrigation Scheme (NAIS) – a once-in-a-generation opportunity for agribusinesses to secure reliable, climate-independent water at stable prices under long-term agreements.

The water will irrigate crops to satisfy demand from booming export markets for quality South Australian produce. NAIS water will aid the development of more than 300 hectares of high-technology horticulture and a further 2,700 hectares of advanced agri-food production.

insideinfrastructure.com.au

EXPERTS FROM RICARDO'S WATER PRACTICE ARE SUPPORTING A SCHEME TO MEET SUPPLY AND DEMAND PRESSURES AND BOLSTER DROUGHT RESILIENCE IN SOUTH-EAST ENGLAND BY TRANSFERRING RAW WATER FROM THE LOWER CATCHMENT OF THE RIVER SEVERN TO THE UPPER REACHES OF THE THAMES

WHY GREEN HYDROGEN NEEDS WATER

Green hydrogen is manufactured using electrolysis that is powered by renewable energy, thus incurring no greenhouse gas emissions from its production. The need to develop green hydrogen infrastructure is widely considered to be essential for leading economies to achieve zero carbon emissions by 2050.

There are claims, however, that a future hydrogen economy could have an impact on the water industry. Water UK's Net Zero 2030 Roadmap states: 'If hydrogen emerges as an alternative fuel then water demand would increase 15 to 20 per cent'.

Pure water is critical for hydrogen fuel production with around five metric tons required per day for every megawatt of electrolyser capacity. This raises the question of how water for hydrogen would be sourced and be made available in the right place, at the right time, and in the right amounts.

A report by Norwegian energy consultancy Rystad Energy has further insisted that nearly 85 per cent of the green hydrogen capacity in the global pipeline may need to source its water from desalination as the vast majority of projects due to be built by 2040 are in water-stressed countries such as Spain, Chile and Australia. Desalination of sea water or brackish groundwater requires additional renewable energy, potentially increasing the overall cost.

"This is a somewhat pessimistic outlook," says Alec Davies, a Ricardo Energy and Environment consultant specialising in hydrogen. "Our modelling of energy flows and water requirements for a typical offshore green hydrogen plant, for example, shows that the power required for a desalinator is only a small fraction of the total. The uplift in the levelised cost of the hydrogen might be around five per cent – which is a comparatively small addition if it means avoiding any impact on local water resources."

This view is supported by a recent survey from the International Renewable Energy Agency which claims the increase in levelised cost [the price at which the generated hydrogen should be sold for the plant to break even at the end of its lifetime] due to water desalination for multi-gigawatt green hydrogen projects in countries such as Mauritania, Namibia, Saudi Arabia and Oman could actually be less than four per cent.

Hydrogen's potential as an offshore

technology is certainly recognised closer to home. Davies cites projects in East Anglia exploring the potential for hydrogen as part of an ambition to become the UK's Clean Growth Region. One project, led by Hydrogen East, is exploring the potential for offshore hydrogen production as part of the Bacton Energy Hub – which is a combination of carbon storage technology, blue and green hydrogen production and collaboration with the offshore wind sector. "Given Norfolk is one of the UK's driest counties, desalination is an option being considered here too by the local water companies," he adds.

In another example of how the production of hydrogen could be accelerated by the water sector, Water UK's Net Zero 2030 Roadmap cites research from Australia that shows potential capital and operational benefits from co-locating the production of hydrogen on wastewater treatment sites and using the oxygen by-product to aerate activated sludge processes. [Read more](#)

PURE WATER IS CRITICAL FOR HYDROGEN FUEL PRODUCTION WITH AROUND FIVE METRIC TONS REQUIRED PER DAY FOR EVERY MEGAWATT OF ELECTROLYSER CAPACITY



Green hydrogen infrastructure is essential for leading economies to achieve zero carbon emissions by 2050

! WASTED ENERGY

Buildings for the future

Ricardo was a major contributor to the independent Climate Change Committee's recent progress report on the UK's legally-binding decarbonisation goals. The report delivered a stark warning: there is 'scant evidence' that the UK will achieve the targets set out in its Net Zero Strategy.



UK homes are among the least energy efficient in Europe



The report¹ noted that while the UK has set emission reduction targets that are internationally recognised as being compliant with the Paris Agreement, credible plans exist for only one-third of required emissions reductions to meet the Sixth Carbon Budget in the mid-2030s. An area singled out for attention was

energy efficiency in buildings. The UK has some of the leakiest homes in Europe while installation rates for insulation are low. Among the CCC's recommendations to Government were the immediate creation of a public energy advice service to help households decarbonise and adapt their homes to climate change,

as committed to in the Energy Security Strategy. In our feature *opposite*, Ricardo's Sujith Kollamthodi describes his own progress towards domestic decarbonisation.

¹theccc.org.uk/publication/2022-progress-report-to-parliament/

Home thoughts

Ricardo's Sujith Kollamthodi has made domestic decarbonisation a personal mission. As we face a cost of energy crisis, he shares his practical and financial insights from the transition process. What are the learnings for business?



The UK's housing stock is old and poorly insulated

In March 2017 I had a 4 kilowatt array of solar panels installed on the roof of my house. I now have five years' worth of data on the costs and benefits of domestic solar power. In that period, my panels generated 19,234 kilowatt hours (kWh) of solar energy. The total cost of the panels, the inverter and installation was £6,800 and I have received Feed-in Tariff (FIT) payments for every kWh of solar energy generated that partially offset the installation costs – £1,379 so far.

On top of that I can make use of solar energy to power the house, displacing the use of electricity from the grid and thereby reducing ongoing energy costs.

Because I have a home battery storage system, I can use just over 80 per cent of the solar energy generated by my panels to power my house, heat my water and run my electric car. What if

I didn't have the battery? Is it still worth getting solar panels on their own?

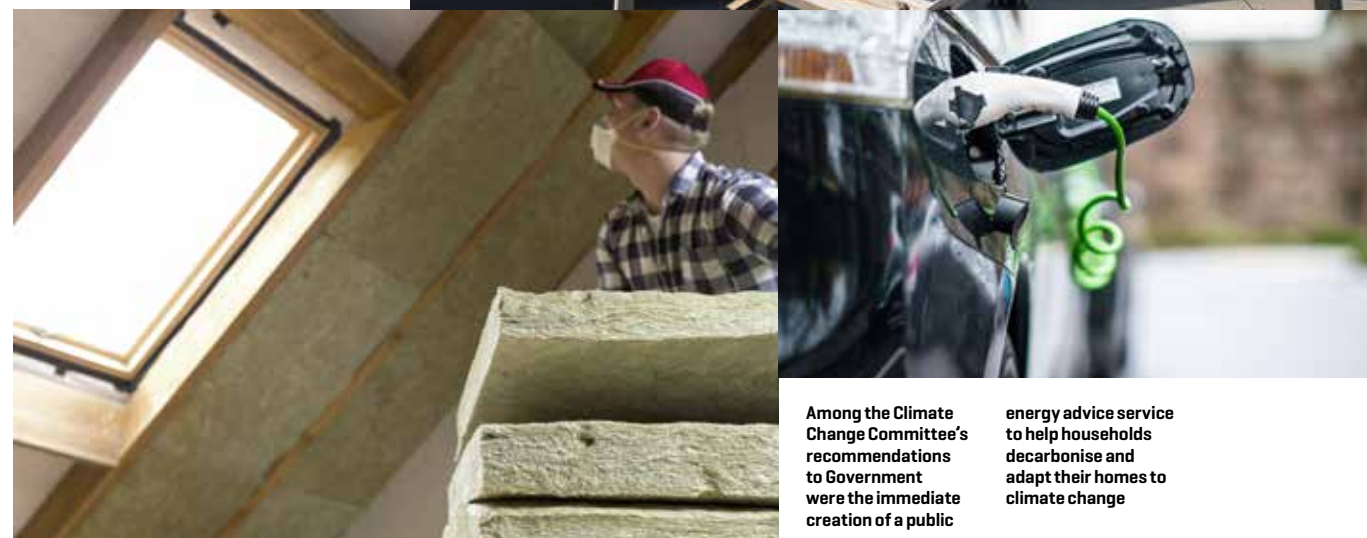
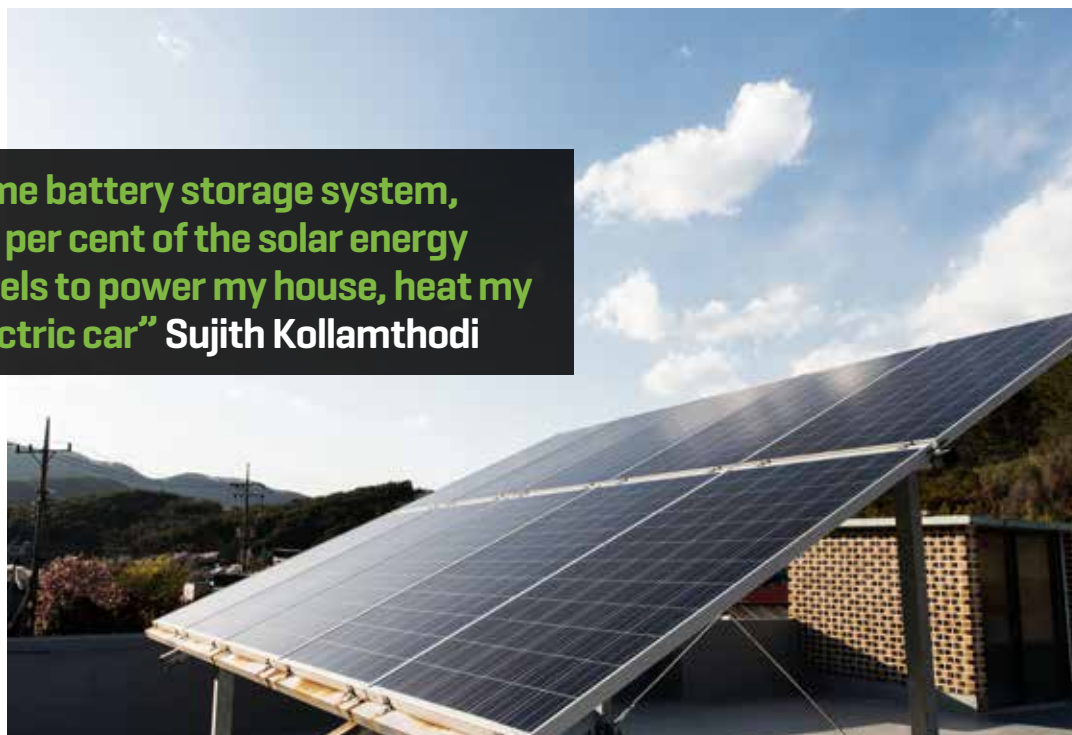
Since March 2017, I have used a total of 17,550 kWh of electricity to power my house and charge my electric car at home. This figure is a combination of electricity from the grid and solar energy generated by the panels. Over that period, the cost of electricity I purchased from the grid averaged 14 pence per kWh. So, without solar panels, I would have paid £2,457 for five years' worth of electricity consumption.

Before I got my home battery storage system installed in May 2018, I was only able to use 20 per cent of the solar energy generated by my panels because most of the time no one was at home during the day when the sun was shining (the remainder was exported to the local grid). Twenty per cent of the 19,234 kWh of solar energy generated is

3,847 kWh, reducing my grid electricity consumption to 13,703 kWh and giving a corresponding cost saving of £539 over five years. With COVID-19 lockdowns and home working, the proportion of solar energy that is usable during the day has shot up and in reality will be much higher than 20 per cent.

What has the total cost of ownership been over the last five years? The installation was £6,800, subtract the FIT payments of £1,379 and also subtract £539 for reduced grid electricity consumption – this gives a total cost of ownership of £4,882. That works out at 25p per kWh of solar energy generated so far. This unit cost figure will of course reduce significantly in the future as more solar energy is generated and I receive further FIT payments. By 2027, the unit cost of solar energy generated by my set-up will have dropped to just

“Because I have a home battery storage system, I can use just over 80 per cent of the solar energy generated by my panels to power my house, heat my water and run my electric car” Sujith Kollamthodi



Among the Climate Change Committee's recommendations to Government were the immediate creation of a public

energy advice service to help households decarbonise and adapt their homes to climate change

→ 5.7p per kWh over the ten-year period between 2017 and 2027.

When will the set-up become cost neutral? This depends on a number of factors including the cost of grid electricity and the proportion of solar energy generated that I use. I will keep receiving FIT payments for 15 more years and these increase each year in line with inflation. Currently the payback period for my solar array would be 15.5 years. However, April 2022 saw the price cap for grid electricity in the UK rise to 28p per kWh and further steep increases are imminent. With these new prices, the total payback period drops to 13.5 years. And the payback point can be brought down even further by increasing my utilisation of solar energy. If we increase usage to 40 per cent then the payback point drops to 10.5 years.

Decarbonising domestic hot water

My house has a modern, conventional (non-combi) gas boiler and hot water storage tank. Hot water provided by the boiler needs to be pumped to the storage tank for use later.

I also have an electric immersion heater fitted to the water tank so I can choose to heat up the water using electricity instead of gas. Traditionally, such immersion heaters were only for 'emergency' use as the cost of heating water with electricity has always been significantly more than with gas. But what if we could make use of electrical energy from solar panels to heat up water in our houses using the immersion heater, or cheap-rate night-time electricity to do the same thing?

In May 2018 I had a solar diverter

system fitted. Instead of excess solar power being exported back to the grid, it is diverted to my immersion heater to provide hot water for free (the 'excess' being the solar energy generated by the panels that is more than is needed to run appliances in the house). Once the water is sufficiently hot, any remaining excess solar power is then exported to the grid. The system also allows me to schedule the immersion heater to use cheap night-time electricity (particularly helpful in winter when there is far less sun).

What does this mean in terms of cost savings? If I heat up water using the gas boiler, this requires around 4.5 kWh of energy per day. Until 1 April this year, the UK price cap for gas was 4.07p per kWh so over the course of a year hot water from the gas boiler would cost roughly £67. The price cap for domestic energy

in the UK has since greatly increased – for gas, by 81 per cent! At these prices, the cost of providing hot water in my house from the gas boiler would increase to around £121 per year.

How does this compare to using the solar diverter and immersion heater? The diverter equipment cost £840 to install and I have found that I can use 'free' solar power to heat my water for around eight months of the year. For the remaining four months I can either use the gas boiler or, since 2021 when I had a smart meter fitted, make use of cheap-rate night-time electricity. Using gas for the remaining four months would cost £40 since the gas price increase in April 2022.

What about using the immersion heater? Currently, my daytime electricity is billed at 15.6p per kWh and night-time electricity (12.30-4.30am) is billed at 5p per kWh. The immersion heater is rated at 3 kW and I tend to run it for 1.5 hours per day to provide sufficient hot water (giving a total energy demand of 4.5 kWh). So, for the four months of the year when there is limited sunshine, getting hot water from the immersion heater would cost £85 using daytime electricity (super-expensive!) but only £27 using night-time power.

In summary, from April 2022 my annual costs for heating water only using the gas boiler will be £121 per year whereas using a combination of solar and night-time electricity via the immersion heater will cost just £27 per year. Based on these costs, the payback time for installing the solar immersion diverter is just under nine years (and less if energy prices continue to increase).

In terms of carbon emissions, if I heat my water using only gas then this will generate 300 kg of CO₂e per year. If instead I use the combination of solar and grid electricity then this will generate just 116 kg of CO₂e per year.

However, remember that the electricity grid is getting cleaner every year and so the greenhouse gas emissions from using the immersion heater will reduce in future years.

Domestic space heating

Heating a home in the UK is typically very carbon-intensive because most have central heating systems with radiators heated by a central gas boiler. According to the English Housing Survey, 86 per cent of dwellings in England were equipped with a gas boiler in 2019; the Scottish Household Survey has a similar figure for households using a gas or oil-fired boiler. This shows that there's a long way to go to reduce our reliance on gas.

It won't be easy: the UK's housing stock is old and poorly insulated (23 per cent of private housing in England was built before 1919). For a house with cavity walls and a loft, applying insulation to both spaces is the first step.

My own house has a loft and I've applied thick insulation but it was built in the early 1930s and doesn't have cavity walls – something that didn't become common until later that decade. This means that to insulate the fabric of the building, I will need to fit solid wall insulation. It's not cheap – I received a quote for well over £12,000!

What else to do? The UK Government has introduced a new Boiler Upgrade Scheme to support the decarbonisation of domestic buildings. This gives £5,000 grants towards the cost of installing an air source heat pump or a biomass boiler and £6,000 off the cost of installing a ground source heat pump.

Heat pumps are touted as the main way for decarbonising home heating but will they work for everyone? As an air source heat pump operates at a lower temperature than a typical boiler, a really good standard of insulation is required for these systems to be effective and

provide sufficient heat. Sometimes, when these systems are retrofitted to older houses, new and bigger radiators are needed to compensate for the lower operating temperatures – adding more cost.

Where heat pumps do work very effectively is in newer, well-insulated properties, operating in combination with underfloor heating (underfloor systems have a much bigger heat emitting area than a radiator so the lower operating temperature of the heat pump isn't a problem). An air source heat pump can typically cost from £8,000 to £15,000 to install.

Are there other ways of moving away from gas boilers? Biomass boilers which burn wood pellets, wood chips or logs are an option, are covered by the Boiler Upgrade Scheme and are suited to buildings which are difficult to insulate. Electric-powered boilers are also more common now but running costs tend to be very high, given how much more expensive daytime electricity is than gas.

There are also heat battery systems that can store cheap night-time electricity as heat then pump this around your central heating system when you need to heat your home. Essentially, the heat battery directly replaces the gas boiler in your existing wet central heating system.

As for me, I'm planning to install far infra-red heating panels in each room of my house. Infra-red heating works as the waves radiated from the heat source travel unimpeded to surfaces, objects and people, producing a natural warmth that feels much like the sun on a warm day. This direct method of heating is exceptionally efficient as almost 100 per cent of all energy used is converted into heat. ☀

Sujith Kollamthodi is Ricardo Energy and Environment's Director of Strategy and Innovation

Down to business

The Climate Change Committee's Progress Report highlights a number of actions to support businesses on their decarbonisation journey, both for those with existing premises and for others planning new developments:

- A strategy for engaging with small and medium-sized enterprises, particularly high-emission, low-engagement businesses, including access to carbon footprinting tools.
- Publication of a timber policy roadmap to increase substantially the use of wood in construction.
- A plan to make assessment of whole-life carbon and material use of public and private construction projects mandatory by 2025 so that minimum standards can be set. The whole life carbon

assessment should be sought at the planning stage to enable efforts to reduce embodied carbon and materials.

- By 2023, publish proposals for a minimum energy performance certificate in owner-occupied commercial buildings.

Planning and implementing net zero strategies can turn threat into opportunity for businesses, reducing risks to operations and increasing resilience and adaptability. Ricardo has a long track record of helping organisations with baselining, developing and implementing carbon reduction strategies and policies and responding to environmental legislation.

Find out more: ee.ricardo.com/net-zero



THIS MUCH I KNOW...

DRAGICA KOSTIC-PEROVIC

Chief Engineer, Ricardo Automotive & Industrial,
on why bringing more women into engineering is
critical for the future of the profession



In many western nations, engineering is even more of a man's world than professions that are notorious for being so, like finance or software development. This is frustrating because there are no obstacles to women studying engineering or entering the profession. The reasons are mainly cultural. This would be a great topic for a PhD psychology student!

In the UK, just nine per cent of engineering professionals are female. A UNESCO report published last year highlighted the fact that in the US only one in five engineering graduates are women. In Japan it's just one in seven. In contrast, the strongest representation of women among engineering graduates is in the Arab States and particularly in Algeria (48.5 per cent), Morocco (42.2 per cent) and Syria (43.9 per cent). In Serbia, too, where I was brought up and completed my undergraduate degree in electrical engineering, many more women studied STEM subjects at university.

That said, after graduating I wanted to come to the UK. British engineers tend to work in very collaborative ways with an emphasis on innovation. This may be a legacy of the long heritage of engineering in this country; it's certainly how we work at Ricardo. I wanted to experience this stimulating culture, to be among people with an absolute passion for what they do and apply the principles of physics that I had first learned about in high school to real-world problems. I joined a group at the University of Sussex conducting research in diagnostics of electric machines and completed my DPhil in electrical engineering.

I will borrow a term from nuclear physics to describe what we must strive to achieve next: critical mass. This applies to all under-represented groups in the profession. There has been some improvement in diversity over the last 30 years but only by a few percentage points. Radical action is needed. This could be a commitment to positive recruitment from under-represented groups or even a formal pledge by employers to work towards 50:50 gender equality.

As a Chief Engineer at Ricardo, I lead large cross-functional projects. Because of my training, most of these are at the heart of the drive for electrification which will have such an impact on our future world. I work with thermal engineers, structural engineers and mechanical engineers as well as electrical engineers, both in the UK and overseas. I really enjoy

the diversity within the engineering domain that comes naturally within Ricardo. And I have never felt disregarded by colleagues and have been accepted by my peers throughout my own career.

I'm proud and honoured to have received the Best Woman Electrical and Mechanical Engineer at the recent European Women in Construction and Engineering (WICE) Awards. Awards like these celebrate the achievement of female engineers and will definitely help to make a difference to improve the diversity and inclusivity of the engineering profession for the next generation. At Ricardo we also have our Engineering Prize, which recognises the most promising female engineering student and rewards the winner with a work placement to enable them to take a positive first step in their career.

I want to see our professional bodies doing more to raise visibility. Compared to medicine or law, for example, engineering receives very little media attention yet it underpins almost every aspect of modern life. The wider public do not know what engineering is or what an engineer does or what type of people they are. By instinct and training, engineers are creative and curious about the world we live in – and that should make them and their work interesting to others.

The WICE award fills me with responsibility. I'm fortunate to work for a company that is dedicated to diversity but it is still my responsibility to speak up, to promote and to explain female and minority perspectives and experiences in everyday situations in the engineering workplace. This is something that I need to do, that I need to act on. As a Chief Engineer, I try to influence where I can. Changing the profession overnight is impossible but I can do small things every day. That always starts with the recruitment process.

My daughter is at the point in her education where she is considering university options. Like me she is interested in physics. She is also an avid motorsport fan. Engineering is definitely a career she is considering. I would like to think that when she graduates, she will apply to join a company, her female perspective will be valued and she will work alongside many more people just like herself. 📧

To mark International Women in Engineering Day, Dragica and her team are featured in a special online photo exhibition, together with engineers, manufacturing specialists, consultants and business leaders at Ricardo: ricardo.com/INWED22gallery

BESPOKE BATTERIES

As vehicle electrification gathers pace, there will be an increasing demand for bespoke battery solutions for niche vehicles. Who better to develop them than Ricardo Performance Products, as its managing director, Martin Starkey, explains to RQ's **Ian Adcock**.

In 2021 Ricardo received UK Government funding to assess the commercial viability of a facility to assemble battery packs for UK manufacturers which produce fewer than 10,000 electrified vehicles per year.

These manufacturers include some of the world's best-known prestige brands, which create their luxury cars, special vehicles or off-highway machines for a customer base in the low thousands. This compares to the hundreds of thousands or, in some cases, millions of vehicles produced for the passenger vehicle market.

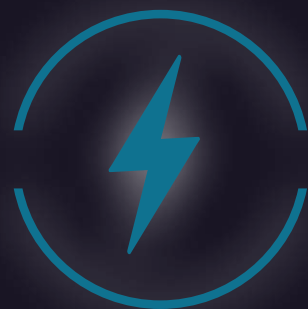
The economic study was funded by the Advanced Propulsion Centre's Automotive Transformation Fund supported by the Department for Business, Energy and Industrial Strategy. The study considered how to meet the particular battery hardware needs of these diverse, low volume manufacturers across a wide range of business sectors, by ensuring a UK supply chain in electric vehicle (EV) components.

RQ: What is the timescale for the project and its principal gateways?

MS: We started with a white paper¹ and developed into a full virtual reality (VR) facility model, ultimately assessing the UK's potential niche battery supply capabilities: not only the ability to supply the battery packs themselves but also the cells, enclosures, wiring looms, cooling systems and so on. In other words, the bill of materials for a high-performance battery pack and its complete supply chain would be located within the UK. We developed a conceptual facility and rendered it in full VR, then assessed the viability of it to assemble and test a full battery pack.

There isn't currently a fixed timescale to develop a facility as such, more a clear set of gateways we need to pass through to reach that goal: step one was a paper study of the UK's readiness to supply itself with niche platform, high-performance battery packs and there are two reasons why we →





“SUSTAINABILITY IN THE SUPPLY CHAIN AND OUR MANUFACTURING PROCESSES HAS NEVER BEEN MORE AT THE FOREFRONT OF OUR THINKING AND BUSINESS THAN IT IS TODAY”

Martin Starkey, Ricardo

→ limited ourselves to this sector: first, quite frankly, it's Ricardo's speciality. Second, the UK is predominantly a niche volume, high-performance vehicle manufacturing sector from Lotus and McLaren to the likes of Aston Martin and Bentley, through to aerospace and defence activities and specialist vehicles such as Dennis and JCB. So we're talking about a battery pack requirement in the thousands to tens of thousands annually.

The next gateway that's currently under discussion is developing a scaled demonstrator within an existing Ricardo site, requiring a prototype battery manufacturing facility capable of showcasing series production pack quality in a safe and appropriate environment.

How much commonality will there be in the different battery packs?

This is both our biggest challenge and opportunity. The cell's format is hugely variable whether it's prismatic, cylindrical or pouch; there isn't even a harmonised view on cell chemistry, format, module size or pack configuration. These variables will require a highly flexible assembly methodology. Done well it provides fantastic opportunity; done poorly it may quickly become a limiting factor. It's for this reason the next step is a scaled prototype facility.

A high-performance car application may require a very power-dense pack for maximum acceleration while range and energy capacity might be secondary, but the weight and shape of the pack could influence vehicle dynamics. At the other end of the spectrum you might have off-highway applications requiring enormous, high-energy packs where the weight and dimensions have more freedom.

A cell-to-pack approach is increasingly popular for improving energy and power density in a pack. The elimination of the module and use of larger format cells reduces the number of interconnections between cells and allows a significant increase in the energy available to fit into the same space. This does, however, pose new challenges in assembly as the pack has more electrical connections to do in final assembly and fewer sub-assemblies to optimise process flow.

It's therefore hard to see any level of commonality between our customers at pack level, but with more opportunities at a module level in particular where end applications are similar. I can especially see commonality [driven by strong commercial advantages] where a business has multiple vehicle lines that all have the ability to share a common cell or module. It's clear that the majority of the cost of a pack sits in the cell and the more that can be done to leverage the positive effects of scale in respect to this, the more commercially viable the final product is.

The white paper mentions power outputs ranging from 130 kilowatt-hours [kWh] to 500 kWh – in what increments?

The brief to the team was to design a facility with any of the current commonly known cell formats that can be used in any sensible module design. Once you have the module, its flexibility is almost infinite because it's predominantly a manual manufacturing operation. The power ranges mentioned related to potential applications in this UK niche.

Will one of the major challenges be tailoring battery packs for individual marques and models?

Yes, but the earlier we get involved in the product design the better. We can then influence the robustness of the assembly, its reliability and, most importantly, the cost of bringing it to market. With this approach we can achieve things like preventing excessive or unnecessary tooling costs, minimise supply chain investment or development costs and ensure things like pack rework and serviceability are considered. The use of manufacturing-based judgments in the design and development process is critical to ensuring a successful product.

600 kilograms is given as an example weight of an EV battery pack. That's a hefty weight for a sports car...

Weight is a fundamental issue, especially to a dynamic vehicle, and 600 kg was given as an example placeholder to demonstrate the scale of a finished production pack. It should be noted that the bulk of that, probably in the region of 400 kg, is the cells themselves. Although there is significant ongoing research in new cell chemistries that are lighter and more energy dense, unless you can significantly move the needle in terms of cell weight you are always going to be constrained in terms of light weighting. The next best thing, for a sports car at least, is to get them low enough down in the vehicle to have the least impact on dynamics.

When it comes to other factors outside of the cells, things like the pack cooling system starts to become more critical. For example, liquid cooling a pack adds more weight than air cooling but it has benefits in energy and power density, improving how fast you can discharge and recharge the battery.

Higher and broader temperature capability of the cells could allow for more options in cooling performance, including more passive thermal options, but with current cells active cooling is expected. Other cooling approaches, like immersion in dielectric fluid, should provide increased thermal control and power density for really high power batteries and will require additional flexibility in assembly.

Why have you opted for pouch cells in the white paper?

When we set out on the study, pouch cells appeared to be the favoured route – although I get the impression that cylindrical and prismatic cells in some areas are making a resurgence and there's some interesting data emerging on the various merits of each.

From an assembly perspective the cell format is not hugely significant other than one specific challenge: how you connect them. There are fundamentally two approaches, either mechanically or by some form of welding; depending on the cell format and manufacturer your joining technology may be fixed. Either way, we can meet our customers' needs as the facility is designed for prismatic, cylindrical or pouch cells.

How can you minimise the supply chain's environmental footprint?

This was a really important element of the study. Part of what we're looking at is how much of the UK supply chain is capable of supplying the sub-systems and components needed for these new battery systems. It's one of the reasons why we went for a 'real' battery design: it allowed us to get drawings and specifications out to companies and ask if they could produce parts in the hundreds or thousands and how they would go about achieving that, while meeting all the various commercial and technical constraints that would be expected in production.


On more than one occasion we had to find entirely new suppliers, sometimes outside automotive and often new to battery applications. By working with their manufacturing capabilities and experience we helped them successfully transition into a supplier capable of meeting the needs of a battery application. It's something we're very experienced in

doing, bringing suppliers along on the journey with us.

Brexit has had an impact as well, as the EU's Rules of Origin require that by 2027, 55 per cent of components must be EU or UK sourced. That will demand the cells are manufactured here in British gigafactories because they make up the majority of the pack. Every additional component after the cells that can be sourced here in the UK further helps with this challenge.

One of the very positive aspects coming out of the white paper has been developing relationships with key suppliers including new UK cell producers. This work has already led to discussions around future technical demonstrators, where Ricardo would take a UK-sourced cell and other domestic components to build a 100 per cent British battery and in doing so demonstrate the UK's ability to meet the Rules of Origin trading requirements.

At a cell level it is a fact that the UK isn't rich in the metals and electrolytes required to support the manufacture of the products and as such these will always require importing. However, this is certainly more environmentally friendly than shipping heavy, less densely packed, chemically-active battery cells around the world. We should remember the purpose of the EV in the first instance is to reduce the tailpipe emissions of the UK's future vehicle production, helping to create a safe and sustainable world.

This sustainability in the supply chain and our manufacturing processes has never been more at the forefront of our thinking and business than it is today. Whether that's using solar power captured at our manufacturing sites or recovering energy when testing our products to feed back into our business. Eliminating, constantly reviewing and reducing our carbon emissions is central to our actions within Performance Products. 

¹Available at: ricardo.com/uk-battery-facility



“ON MORE THAN ONE OCCASION WE HAD TO FIND ENTIRELY NEW SUPPLIERS, SOMETIMES OUTSIDE AUTOMOTIVE AND OFTEN NEW TO BATTERY APPLICATIONS”

Martin Starkey, Ricardo



BRAIS IN BRIEF

Title: Principal Economist with Ricardo's Energy & Environment business unit

Background: Master's degree in Economics, London School of Economics; Senior Manager, UK Government; Senior Manager, Economics, Deloitte; joined Ricardo in 2020

A day in the life...

BRAIS LOURO

Why Ricardo will always take Pride in the job

This is a significant year for the Pride movement and the LGBT+ community. It's half a century since the first Pride rally took place in the UK; 2022 is a chance to acknowledge the achievements of those who have come before us but also to recognise the challenges still faced by our community and continue to fight against injustice and inequality.

At Ricardo, our Pride Working Group organised a month of activities using the tagline 'Educate, Celebrate and Donate with Pride'. We were delighted that CEO Graham Ritchie spoke at the opening event to explain why it is important to celebrate Pride in the workplace and to reaffirm the company's commitment to diversity, equity and inclusion [DEI].

Our final event was a panel discussion on allyship, which is widely regarded as a key to unlocking the full potential of diversity. Allyship is about investing time to support others, for example by championing someone from an under-represented community; addressing unconscious bias; trying different recruitment methods; or using inclusive language. We want to explore ways to promote DEI within Ricardo and create a culture that is even more inclusive.

At Ricardo I am currently leading and contributing to multiple projects for the European Commission, the UK Government and business associations, supporting the policy development cycle by assessing the socio-economic and environmental

impacts of policies, especially in relation to the EU Green Deal.

As an economist and social scientist, I also contribute to a diverse set of projects, for example, analysing and quantifying the potential impacts of environmental pollution and climate change across different economies to help governments and other social actors identify and prioritise their course of action.

My passion for this subject dates back to my time as a college student when I explored participatory development – the concept that equitable and sustainable growth in a community or enterprise will be more likely to occur if the whole community or workplace is engaged and empowered in the process. I was able to see this in practice when I spent some time working with non-governmental organisations in parts of South America, West Africa and the Caribbean. Ricardo's flexible and international environment attracted me to the company along with its fundamental commitment to help build a better future.

I've been involved in DEI networks for similar reasons: I want all my colleagues to feel they can bring their authentic selves to work, to be able to be who they are. If we have to hide part of ourselves in the workplace, it makes it really hard for us to give our best for our customers and our team-mates.

Building on this, I co-founded the Energy & Environment business unit's LGBT+ forum to complement existing forums on gender,

"I WANT ALL MY COLLEAGUES TO FEEL THEY CAN BRING THEIR AUTHENTIC SELVES TO WORK, TO BE ABLE TO BE WHO THEY ARE"

disability, race and ethnicity. The forum's objectives include developing community; gathering evidence, especially of the experiences of professionals in our business unit who identify as LGBT+; and raising awareness and sharing best practice.

I'm also a member of Ricardo's DEI Council, which brings together colleagues from across the company. It's a safe space for conversations that can sometimes be challenging.

We want to create a workplace where everyone can thrive no matter their background, ethnicity, gender, gender identity and sexual orientation, age, functional and/or neurological differences, religion or beliefs.

I researched Ricardo's culture before joining and I've found that DEI is indeed woven into our talent acquisition and development processes and the ways in which we do business. That said, there is still more to be done.

Pride is an opportunity to celebrate all the progress achieved in its 50+ years, and this is one of many reasons why the next half-century is just as important. [RQ](#)

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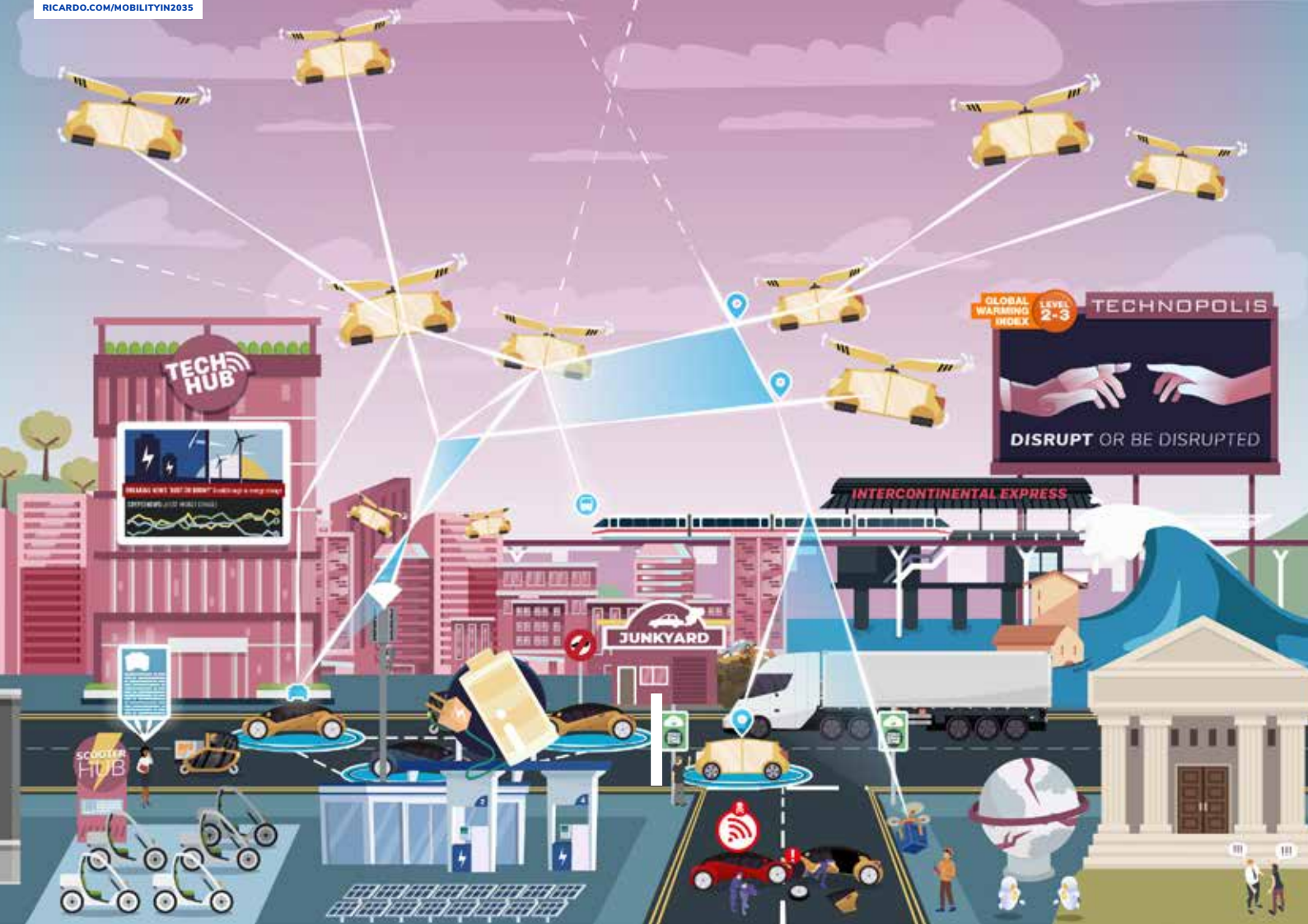
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