The Marrakech conference injected new momentum into the world’s fight against climate change. Ricardo specialists were there, assisting countries developing their mitigation, adaptation and finance strategies.
CO\textsubscript{2} and fuel-consumption improvement

With increasingly stringent emissions and CO\textsubscript{2}/greenhouse gas regulations applying around the world, coupled with the challenge to optimize fuel efficiency, reliability and total cost of ownership, Ricardo is uniquely placed to assist customers with their next-generation engine engineering projects, across a variety of applications.

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With increasingly stringent emissions and CO2/CO2 and fuel-consumption improvement, Ricardo’s facilities for accurate measurement of •

Novel thermodynamics – split cycle for > 55% brake

Connectivity and Advanced Predictive Control

Electrification/hybridization

Waste-heat recovery

Smart management and electrification of ancillaries

Efficient combustion – patented Twin Vortex

Low-friction coatings

Downsizing/downspeeding

Engine design for low friction

The task of RQ is to highlight the latest thinking in global engineering and technology in the transportation and clean energy sectors and related industries. We aim to achieve this by presenting an up-to-date mix of news, profiles and interviews with top business leaders, as well as in-depth features on programmes – both from within Ricardo and other leading companies.

Putting innovation into practice

Impartial expert advice is vital if high-potential innovations are to be brought successfully from concept into commercial reality. Clear guidance in steering projects from Technology Readiness Levels 1 to 6 can be especially valuable, says Anthony Smith.

Ricardo Quarterly Review • Q4 2016
Electric vehicles and their infrastructure are becoming mainstream business for major automakers as leading brands announce dedicated architectures for battery-powered models, and a consortium of six German producers plans to deliver a high-powered charging network to allow long-distance travel across Europe for drivers of electric cars.

Following the debut of modular electric-car platforms from Daimler and Volkswagen at October’s Paris auto show, Jaguar Land Rover has become the latest automaker to demonstrate it is serious about zero-emission vehicles. The Jaguar I-Pace Concept, unveiled in Los Angeles in November, previews a full production model slated for market launch in 2018 and is built on an all-new architecture specifically laid out for battery power. The 4.6-metre five-seater hatchback has twin 200 hp electric motors, all-wheel drive, and a 90 kWh battery claiming the new-generation EV benchmark range of 500 km on the EU cycle, corresponding to 220 miles under EPA test conditions.

Shortly after the announcement, Jaguar confirmed that electric-car production would generate up to 10,000 additional jobs in the UK.

Jaguar’s move comes against a background of growing confidence around electrified vehicles. A joint study by Bloomberg and McKinsey predicts that by 2030 two-thirds of all cars in the world’s 50 biggest cities will be electric; Europe’s EV population will exceed 600,000 units this year and sales of Nissan’s pioneering Leaf have already passed the quarter-million mark. Further encouragement comes from the decision by Toyota, a long-term sceptic about battery-electric cars, to offer a production EV from around 2020.

An additional incentive for EV uptake will be provided by the new European charging regime planned by a joint venture between BMW, Daimler, Ford, VW Group and Porsche. The fast-charge network will initially roll out some 400 sites across the continent offering recharging at up to 350 kW – much more powerful than today’s installations, and dramatically cutting refuelling times for drivers. By 2020, customers should have access to “thousands” of charging points, says the joint venture.

“This high-power charging network provides motorists with another strong argument to move towards electric mobility,” said Harald Krüger, CEO of BMW. In parallel, outgoing US president Obama’s announcement of 48 fast-charging corridors across the nation’s interstates will boost North American interest in EVs as a long-distance as well as urban travel solution.
Field’s observation that while the keynote address to AutoMobility LA, Declared Ford CEO Mark Fields in his Mobility: the bigger picture, hopes to have a fleet of 100. Paralympic Games open in 2020 Toyota 2017 and by the time the Olympic and two will begin taking passengers in for the Tokyo Bureau of Transportation; car already on sale.

Philosophy as the Mirai fuel cell passenger trailer technologies based on the same at the options for zero-emission semi-hydrogen-powered heavy trucks, too. A go into service, Toyota has announced At the same time as its FC fuel cell bus Fuel cells for heavy duty

At the same time as its FC fuel cell bus goes into service, Toyota has announced it is exploring the opportunities for hydrogen-powered heavy trucks, too. A California-based feasibility study will look at the options for zero-emission semi-trailer technologies based on the same philosophy as the Mirai fuel cell passenger car already on sale.

In the meantime, the Toyota FC Bus (below) is to enter service on fixed routes for the Tokyo Bureau of Transportation; two will begin taking passengers in 2017 and by the time the Olympic and Paralympic Games open in 2020 Toyota hopes to have a fleet of 100.

The FC Bus is powered by two of the 114-kW fuel cell stacks found in the Mirai and stores some 235 kWh of energy in its ten hydrogen tanks running at 700 bar. The bus is also able to act as an external power source in emergencies such as earthquakes and floods, and can deliver a supply of up to 5 kW.

Volvo, meanwhile, has inaugurated a further electric bus charging station on the 55 route in its home city of Gothenburg. Fitted by ABB, the 150 and 300-kW opportunity charger can provide 30 minutes of drive time in a typical three-to-six minute stop; the open interface between the charger and the bus is designed to ensure that buses are compatible with chargers from all equipment suppliers.

Batteries beat fuel cells, says study

Battery-electric vehicles have often been regarded as a stepping stone on the way to the dream power source of hydrogen, but a new study focusing on California says that battery power could be more effective overall in reducing CO2 emissions from transport.

Researchers from Stamford University in California and the Technical University of Munich looked at the likely effects of different penetration rates of both technologies and concluded that fuel cell vehicles would have to become much lower in cost to be able to compete with battery models; while a hydrogen refuelling infrastructure could be built up using solar power, peak solar generation could more easily be absorbed by load shifting through EVs connected to the electricity grid.

Mobility: the bigger picture

“We are on the cusp of a mobility revolution,” declared Ford CEO Mark Fields in his keynote address to AutoMobility LA, the new identity of the Los Angeles auto show. Fields made the observation that while the typical distances travelled had increased dramatically over the 120-year history of the automobile, travel times had remained remarkably constant at 1 to 1½ hours.

Under the Ford City Solutions programme, said Fields, Ford would market a fully autonomous vehicle in 2021, for ridesharing, and that it would have “no steering wheel, no gas pedal and no brake.”

“We will see substantial revenue opportunity in providing mobility solutions to millions of commuters in the US and the growing work force in several major cities globally — many of who do not own vehicles today or do business with Ford,” concluded Fields.

NEWS IN BRIEF

Highlighting the latest thinking in automotive engineering and technology worldwide

Concrete absorbs CO2:

Cement-based construction materials such as concrete are generally viewed as environmentally damaging, yet, counterintuitively, researchers have found that, over time, these products reabsorb much of the CO2 emitted when they were first produced. In an article in Nature Geoscience University of California, Irvine, professor Steve Davis asserts that concrete absorbs progressively more CO₂ during its lifecycle progresses.

Audi rethinks the assembly line

Many automakers, notably, have tried to come up with alternatives to the familiar moving assembly line, but none have met with success. Yet Audi has high hopes for its latest idea – assembly islands – to give the flexibility now needed as conventional cars mix with electrics and hybrids in the same plant. The system, where robots bring the vehicle to each assembly island, allows vehicles to bypass stations that are not needed, meaning the whole assembly line does not need to run with the same takt time.

Alaskan Airlines flies on biomass fuel

A reduction of some 70 percent in CO₂ emissions is claimed by Alaskan Airlines for its first commercial trial of biomass jet fuel. The November flight from Seattle to Washington used a 20 percent blend of sustainable biofuel, derived from forestry products such as tree branches and stumps that would otherwise have been incinerated. Added benefits of the new process include quicker removal of the leftover wood, allowing speedier replanting of new trees.

Meet Lynk & Co, the newest car brand

Designed in Sweden, built in China and sold online, Lynk & Co claims to be the first-ever digital auto brand and the first to offer open-platform access to outside innovation for services and applications. The creation of Geely, which owns Volvo, Lynk will offer premium cars built on safety-proven Volvo architectures and will launch its 01 “bold and tech-laden” medium SUV in China in 2017.

Fill her up

High net worth individuals driving gas-hungry super-luxury limousines will soon be able to avoid the messy process of mixing with ordinary people as they fill their cars with fuel. Bentley customers in California will be invited to take part in a trial which sees the special Filld for Bentley service bring the fuel direct to the customer’s car, whether at home or at the office. A special app will pinpoint the car’s location for the service, and the car can even pre-order fuel when it is running low.

Samsung targets the car business

Korean electronics giant Samsung appears to be mounting a challenge to Apple, Microsoft, Google and Uber to claim a stake in the fast-expanding market for automotive connectivity. Samsung’s purchase of Harman International, which includes key car audio brands Harman Kardon, JBL and Mark Levinson, will give it immediate access to the world’s leading automakers.
Combustion engines fight back

Earlier this year the BMW Group presented a series of futuristic concept designs to celebrate the company’s centenary, but there was a disappointing lack of detail on how the group envisaged the propulsion of these future vehicles. Delivering an address to the Aachen Colloquium in October, BMW R&D head Klaus Fröhlich gave an outline of the group’s thinking, but again details were sparse.

There is no such thing as a one size fits all approach, he said, conceding that the combustion engine would decline in the medium term despite the evolutionary advances still being made. Short-range vehicles up to 200 km would be battery powered, he said, while medium ranges would be covered by plug-in hybrids. For longer trips and heavier loads hydrogen fuel cell power “was ideal”, and would be viable on a large scale within ten years. Benefiting from its partnership with Toyota, BMW would launch low-volume fuel cell models “early next decade”, he said.

Daimler gave further details of its all-new generation of modular four-, six- and eight-cylinder engines. On offer will be a wide range of technologies including electrification from 12V to 48V, electric supercharging, integrated starter-alternators, cylinder shutoff, particulate filters for gasoline engines, near-engine exhaust layouts, and 2500-bar injection for diesels. Many of these innovations will feature on next year’s revised S-Class.

Solar advance continues

More money is now invested in solar power generation than any other single energy source, and by 2025 more than half the world’s expected 2000 to 3000 GW of solar power capacity will be economic – these are among the findings of the new report in the McKinsey Quarterly. Entitled How Solar Energy Can (Finally) Generate Value, the study says that growth in the solar sector will transform energy markets around the world.

However, in order to achieve better viability, the solar industry will have to achieve greater standardization of design and embrace improved EPC [engineering, procurement and construction] techniques, the report counsels.

Independently, researchers at the US DoE’s Berkeley Lab have been developing techniques for artificial photosynthesis. Mimicking the process employed by plants, the combined photocell and electrolyser works by turning sunlight, atmospheric CO2 and water into fuel.

Exotic materials for exotic bikes

The technology race in the sports bike sector is shifting focus from ever more powerful engines to increasingly exotic frames, with both Ducati and BMW set to launch flagship models with carbon fibre chassis next year.

Ducati’s 1299 Superleggera, ridden into the presentation at the Milan show by Casey Stoner (below), mounts the Italian firm’s desmodromic V-twin, now giving 215 hp, in a carbon frame complete with composite swinging arm, subframes and wheels; BMW’s HP4 RACE, billed as a research demonstrator, also has a carbon frame (above) and wheels but what appears to be a conventional swinging arm.

Neither company has yet given full details of these next-generation superbikes, short of confirming that they will be available in strictly limited numbers – a factor sure to push up their prices towards six figures.
Honda’s 3D-printed microvan

Japan’s hardware and software specialist Kabuku has collaborated with Honda to produce a compact commercial van based on the automaker’s MC Beta EV. What makes the Micro Commuter special is that a large number of its components are produced using 3D printing techniques.

Car Design News reports that Kabuku’s Rinkak software was used to generate the exterior bodywork, which will be using the van to deliver its famous Hato Sablé dove-shaped shortbread: the 3D printing techniques have allowed Kabuku to create an intricate split tailgate design with intertwined dove logos forming the exterior surface.

Dubai trial planned for Hyperloop

The Hyperloop One rapid transit system, originally proposed by Tesla founder Elon Musk, is to target Dubai as its first operational location. A study is to be conducted into the feasibility of potential routes in the region and will report back next year.

The near-supersonic system, which propels passengers and goods in special pods along low-pressure tubes, would give a 12-minute travel time between Dubai and Abu Dhabi, and would link to Riyadh in 48 minutes. There is also the suggestion of adding a line to Qatar in time for the 2022 FIFA World Cup football tournament.

Following a deal struck in October, Hyperloop One’s lead investor is DP World, the Dubai ports authority. Working prototypes of the innovative system are being developed in the US and Hyperloop’s engineers are confident that their networks will be cheaper – and faster – than high-speed rail.

VIEWPOINT

The auto industry can learn from rail in autonomous vehicle safety
David McShane – VP of business development, Ricardo Inc

There can be little doubt that the world is urbanizing fast. According to United Nations statistics, more than half of the world’s population now lives in urban areas, and this number is expected to increase to 66 percent by 2050. By 2030, it is projected that there will be 43 so-called ‘megacities’, and managing these fast-growing, densely populated conurbations will pose numerous challenges – including meeting the need for efficient transportation.

We urgently need to improve the efficiency and sustainability of transportation, and we need to make it safer

Today’s world of mobility is thus dramatically changing in response to this increasing urbanization and the increased traffic congestion it generates. We urgently need to improve the efficiency and sustainability of transportation, and we need to make it safer. The rapid development of autonomous vehicle technology – both by the major established automakers as well as by a number of new market entrants – is clearly underway. With many partial autonomy systems already implemented in products that customers can buy today, the drive towards conditional and then full autonomy is clear, with many predicting that the first fully driverless commercial passenger cars could be on the road by 2025.

A safety assurance gap – where lessons can be learned from rail

Around the world, safety policies and regulations are evolving fast to keep pace with advances in autonomous vehicle technology, and this is something that presents a need for new processes to achieve safety assurance. In many respects the international railway industry is running many years ahead of the automotive industry in the development of safety cases for autonomous and automated systems.

Driverless trains have existed for many decades, allowing dramatic increases in the complexity of automated mass transit systems since the early 1990s. The safety assurance record of the railway industry is also extremely good, and as the automotive sector moves towards the high-level automation of road vehicles, there are many lessons to learn from the rail sector that can help us ensure that the autonomous vehicles of the future are truly safe.

As outlined in one of the main features of this issue of RQ, Ricardo Rail is extremely active in the area of providing independent safety assurance services for some of the world’s newest, most complex and sophisticated railway systems. Recognizing the emerging need for these skills in the development and implementation of the next generation of autonomous road-going vehicles, the company is already applying its extensive skills base and experience to transfer its knowledge to projects in Europe and elsewhere, including truck platooning and autonomous public transportation vehicles. Ricardo is thus helping to bring forward this new paradigm of autonomous vehicles that can deliver increased efficiency, asset utilization and, most importantly, safety.

To share our perspectives on this subject, we recently published a white paper Building a Safety Case for Automated Mobility: Smart Cities and Autonomous Mobility – Getting There Safely at the Automobility 2016 event in Detroit. For those who were unable to attend, but who have an interest in the future safe implementation of autonomous vehicles, I recommend downloading a copy of the paper from: www.ricardo.com/connected.
What is the impetus behind your Generation EQ concept? Is it to see off the challenge presented by Tesla and its likes?
The task for developing our Generation EQ show car came from general environmental factors: firstly, the clean energy act and, secondly, CO2 or fuel efficiency policy. For example, in Beijing or Shanghai you get a free licence for an EV but not for a combustion-engined car.
We also checked if there is a feasible plan in the future for an A-segment EV to compete with a combustion-engined rival based on price, power and range. Is there a tipping point where the new technology and old technology are on the same level? As soon as we established that the environment is moving forwards to something with lower CO2, or even zero, and our internal performance measures found there is a chance to compete with existing technologies, we got the decision to go ahead with this new architecture.

Could you give us more detail about the new architecture you have developed for Generation EQ?
We defined a concept that can provide architecture ranging from a compact car platform right up to the luxury segment that can be built on existing production lines alongside internal combustion powered cars.
The platform will be flexible enough to be front-, rear-, or all-wheel drive and of variable length and width. It will have battery packs that take us up to whatever we want in terms of power, driving electric motors on either the front or rear axle or both. Performance will range from [that of] a small four-cylinder through to a big eight- or 12-cylinder with the same power and torque.

You talked about a ‘tipping point’ between EVs and combustion-powered cars. Could you be more precise?
A good question, and one that’s difficult to answer. But there is a chance that at some point in the future an EV will have the same cost basis as an internal combustion engine. When that will be, we are unsure, and you can’t predict or promise what’s happening in the future — but there will be a tipping point. It depends on how many customers buy the cars, how many of our competitors will develop EVs, future fuel costs, how many battery factories will be built in the world, and how will costs improve with battery technology.

We developed a hybrid human and mathematical, intelligent oracle that tells us it’s time to do it. Even so, there will be a transitional phase, for how long we don’t know, with combustion engines, plug-ins and EVs growing, so we expect by 2025, 25 percent of all vehicles we sell, globally, could be electric. By then there will be more than 10 models, from the smallest to the biggest, with a solution for every customer in all the segments. They will be launched over a number of years, so that over time we will complete this new brand with a portfolio that’s equal to the existing range.
Talking of range, how do you intend overcoming range anxiety and issues surrounding recharging times and convenience?

We have a battery solution for the size of our EQ show car which provides a 500 km range. This is already in development and we will see it in the first series-produced EQ model in three years. Battery energy density we predict will increase about 14 percent a year, which effectively doubles battery energy density every five years: we call it the Hopeman rule.

Up to 2023, I would say we will use today’s technology but with improved thermal and surface management. There will also be technical improvements leading to new chemistry in the next decade; so that by ‘23 or ‘25, we are certain this 14 percent annual gain will accelerate over the next decade. I am still talking about lithium battery technology, but with more emphasis on sulphur, making the battery lighter and cheaper.

From the existing vehicles we have in the market today, and plug-in hybrids, we see that 85-90 percent [of the market] is covered with a range below 60 miles, maybe even less, and for them the standard AC 11 kW charging method at home or work will be sufficient. For the 10-15 percent wanting a longer range there is some infrastructure in place delivering 50 kW. From there we see the charging infrastructure going from 50 kW to 70 kW and up to 120 kW, 150 kW and 300 kW, and we will follow that with a roll-out of new products. With the 150 kW charging option you would charge 60 miles [100 km] in under 10 minutes, whilst with 300 kW we can imagine 60 miles range in under five minutes – that’s the plan.

Extending battery range and reducing charging times is only part of the challenge. Don’t the electric motors need improving as well?

You’re right, and I would invest in developing electric motors rather than bigger batteries. Today, we aim for electric motor efficiency exceeding 88 percent and these motors have a development map, too. It has been the same as for our colleagues who have spent 130 years improving the internal combustion engine: for us it’s the starting point to do that with electric motors.

If you use a permanent magnet motor they have better performance at low speed, whereas an asynchronous motor is more efficient at higher speeds. So, it could be for an all-wheel drive we have one permanent [magnet] motor on one axle and an asynchronous one on the other axle, although that has yet to be decided; an intelligent control system would switch between the two to achieve better efficiency than by using two of the same technology.

Will the emergence of electric vehicles require a big shift in the energy market and central government investment? And won’t this be coming at a time when the global economy, in the EU in particular, is stagnant?

In Germany, two percent of energy comes from wind and so on, with a predicted growth rate of four percent per year on year. If that growth in generating electrical power continues, we don’t see a problem of coping [with demand]. We already have the situation in Europe where turbines are shut down because they generate too much power. If we have EVs on charge overnight we can keep the turbines running. There is more energy available than we currently require, and as far as we see there’s no restriction on EV numbers even if we exceed the predicted growth rate.

Jürgen Schenk is director of E-drive integration at Mercedes-Benz Cars. He joined the research laboratories at Daimler-Benz AG in 1980 and worked in gasoline engine control systems development until being nominated as director for powertrain electronics development in 2002. Given charge of all Mercedes-Benz hybrid programmes in 2003, he was also responsible for all Mercedes-Benz compact electric cars and Smart electric vehicles up to 2015.

Can you explain your new MEB architecture for electric models? Is it sufficiently scalable in terms of track and wheelbase to cover all vehicle segments from the Up! through to the Touareg?

The scalable structure of the MEB [Modular Electric Drive Kit] platform is envisaged to allow it to cover the segments from Golf to Passat and Tiguan. We have already had great experience with the MQB [transverse] and MLB [longitudinal] architectures, so we confidently look forward to the new modular system’s introduction.

Does that mean MEB is also flexible enough to be RWD, FWD and AWD as well?

To achieve a good weight distribution between front and rear, the I.D. showcar is a rear-wheel drive vehicle. But the new MEB architecture, especially developed for electric vehicles, offers high flexibility in terms of drivetrain configurations, including all-wheel drive versions.

Will MEB be made available to other brands within the group, and have the other brands had an input into its configuration?

Within the Group, there are various responsibilities for the modular kits. Volkswagen has the lead for the MQB as well as the MEB development. During the development process we take the requirements of the different brands into account. The MEB will definitely be used by other Group brands to develop an interesting portfolio of new electric cars with a high driving range.

When it comes to production, will MEB-based products use the same manufacturing and assembly lines as combustion-engined models, or do electric vehicles demand a unique process?

Currently we are investigating the options before us, but we have not made a decision yet. Our aim is to produce MEB vehicles in the same factories as MQB-based cars. So far this has worked well with our electric vehicles, such as the e-Up!, e-Golf, Golf GTE and Passat GTE.

Will you use lightweight materials such as carbon fibre to offset the weight of the batteries and minimize mass in the MEB?

During the development of a new car we have to take many factors...
We are continuously monitoring battery development to ensure we offer the best package to our customers. At the moment we are expanding the capacity of the battery in the e-Golf and we will continue this development. We expect significant advances in battery technology, with energy density continuing to increase.

And what about charging times – how do you see these reducing in the future?

Batteries with higher ranges change everything. When batteries offer ranges of up to 370 miles, the focus won’t be on charging times any longer. Vehicles will be charged during standstill times, whilst for long distance journeys fast chargers will reduce charging times.

What is the potential for inductive charging?

In my opinion, inductive charging has very good potential because it is very comfortable and easy for the customer. Ideally, no conventional charging process is needed – that means no visit to a charging station. By the way, this is also a big advantage compared with conventional cars. The car will be charged when it is parked.

Dr Frank Welsch was named board member for development at Volkswagen in December 2015. He began his career in 1994 as project manager for vehicle concepts at Volkswagen Group Research. After various positions in Germany and China he took charge of bodywork, equipment and safety development at the Volkswagen Passenger Cars brand in 2011, becoming board member for technical development and design at ŠKODA Auto in 2012.
Fresh from their participation in the COP22 summit in Morocco, Ricardo’s top team of environmental specialists is closely involved in helping a wide range of nations to begin putting their agreed climate change mitigation and adaptation measures into practice. **Tony Lewin** senses a new mood of optimism.

There was general euphoria after the 2015 COP21 climate conference in Paris where the world’s nations committed to a programme of greenhouse gas (GHG) and climate adaptation measures to address the worsening impacts of climate change and keep the rise of global temperatures to ‘well below’ 2 degrees Celsius.

The most important outcome of Paris was that all these disparate nations and organizations had united on the general direction of travel and were prepared to sign up to legally-binding commitments.

Already, 194 nations have signed and 116 parties have ratified the Paris Agreement, representing almost four-fifths of total GHG emissions. As a result, the agreement came into effect on 4 November, less than a year after its text was agreed.

But while Paris proved great on ambition and broad principle, it provided little detail on the realities of getting the job done. All knew that the biggest challenge would be the move from brave words to concrete on-the-ground action – and these were the tasks left to the follow-up conference, COP22, eleven months later in Marrakesh, Morocco.

Specialists from Ricardo Energy & Environment played an important role not just in the formal conference proceedings by providing technical advice to country delegations but also in the all-important side events showcasing work done by countries to date. The unexpected speed with which the Paris agreement came into force meant a major shift in focus. Suddenly, theory had to be turned into practice – as Chris Dodwell, director of Ricardo’s climate change and sustainability practice, explains:

“The fact that the agreement had come into force earlier than expected meant there was a lot for the COP to get through. The main difference was that the whole agenda was about action, rather than negotiation. So there was a very big focus on what countries were doing about implementation, something that doesn’t really get discussed in the formal negotiating structure. This meant that the side events – the areas in which we [as Ricardo] spend most of our time – were a more vibrant and exciting place than they had been in the past. "Ricardo had a bigger presence than at previous COPs," continues Dodwell. "We were invited to participate in a lot more events because our agenda is much more about action and implementation than negotiation. In fact some commentators are saying that, going forward, future COPs should flip the focus so that the main spaces and the main halls are given over to discussions on implementation, with the negotiations taking place in side chambers."

Dodwell’s colleague Emelia Holdaway, who leads Ricardo’s international climate change policy team, is equally positive, though pragmatic about the challenges of the tasks ahead. “The priority is to maintain the momentum from Paris,” she says. “Countries have a very strong sense of the scale of the challenge, and I think that the donor community is up to the task and is rallying the resources to support them. One of our key roles is to make sure countries get access to the resources that they need, so that we can see implementation happen.”

Ricardo’s role at the conference

Reflecting Ricardo’s close involvement in a conference majoring on implementation of countries’ NDCs (Nationally Determined Contributions, see panel), one of the key tools discussed was the so-called Quick Start Guide to NDC planning and implementation. Compiled by Ricardo and the Climate and Development Knowledge...
“Investing in low-carbon technologies in developing countries is still seen as a bit of an unknown. What we now have to do is demonstrate how to attract private-sector investors at scale” Chris Dodwell, director of Ricardo Climate Change and Sustainability Practice

Over the past year, Ricardo has been working with the Climate Policy Initiative, Baker & McKenzie and AECOM, to develop the GNlplus concept with the stated mission of "helping selected countries develop and enhance the legal, policy, financial, institutional and governance frameworks to drive economy-wide transformations in energy and land use. It will support governments to mobilize private investment at scales that can deliver impact on climate change and sustainable development within the context of the Paris Agreement and Sustainable Development Goals."

GNlplus, says Chris Dodwell, is something of a departure for Ricardo. "This is a high-quality consortium of private-sector actors who understand the public policy space. What we’re trying to pilot are models for getting that private-sector investment flowing at scale into interventions in developing countries that will be part of the [NDC] implementation.

Towards the end of the Marrakech conference, The Netherlands announced that it would provide the first funding to launch the consortium, opening the door to GNlplus to begin working in its first pilot country, Kenya, to mobilize finance for resilience-building projects in the water sector. "We’re hoping this will lead to a bigger tranche of funding,” says Dodwell. "This [pilot] would enable us to put a team on the ground to work alongside the government officials and get them ready to go to the market to raise finance for major infrastructure investments. Over time, we hope that the GNlplus team will be looking at all of the implementation landscape.”

Ricardo’s Emelia Holdaway speaking on the panel discussing the GNlplus initiative to increase private-sector investment in climate interventions in developing nations

Previous page: Ricardo’s Christopher Garth, head Chris Dodwell presenting at a Ricardo-led side event on the implementation of NDC programmes

Network (CDKN) and drawing on previous experience supporting many nations with their NDC preparations, the guide provides a step-by-step approach to the daunting task of NDC implementation by breaking down the activities into discrete, achievable goals.

"Last year we supported more than 15 countries in preparing their INDCs, now called NDCs as countries ratify the Paris Agreement," says Holdaway. "We’re currently supporting one of the last INDCs to be submitted to the UNFCCC, and it is my job to support the country to review and finalize it."

The Quick Start Guide and its modular approach have gained a lot of traction among countries at all points on the development pathway. "I suppose we were the first to market with this type of thought leadership," says Dodwell, "and it has brought us many contacts leading to lots of good meetings at the COP with both donors and countries wanting to use the Guide.”

The other major takeaway from the Marrakesh conference is a renewed sense of confidence, reckons Dodwell. "It’s a virtuous circle, really; a lot of the countries we have been working with have gained greater confidence from the planning and preparation they have undertaken. In turn, their confidence and their boldness in the discussions are attracting positive comment and they are attracting further offers of support and assistance."

Assisting countries with their plans

Two particular countries are worthy of special mention, believes Dodwell: Bangladesh and Nigeria. "Both of them are strategically interesting and fascinating to work with because, with large and growing populations, they are potentially really big emitters in the future, but each are now looking to adopt low-carbon pathways to economic and social development," he explains. "So the decisions they make about their energy mix will have a big impact on future emissions."

Nigeria, for instance, is looking to issue a green bond early in 2017 to finance its NDC, which drew much attention at the COP, and Dodwell chaired a side event to discuss this, featuring speakers from the World Bank and Climate Bonds Initiative. Bangladesh was on the panel in the Quick Start event facilitated by Emelia Holdaway, and used other events to showcase the work on NDC implementation which Ricardo has supported to date, attracting positive comments about how much progress the country has made since Paris.

What’s holding implementation back?

In the broadest terms, the consensus is that it has been a combination of patchy finance, inadequate know-how and a lack of political will that has historically held back the implementation of climate mitigation and adaptation measures. But the new mood within the climate community has seen a softening of some of these barriers – perhaps triggered by greater clarity around the potential economic and social benefits which can flow from the adoption of national climate change plans and how sector-based plans can fit more closely with existing and planned national development.

Yet, says Emelia Holdaway, political will among governments is still something of a sticking point as the target of restricting temperature rise to 1.5 to 2 degrees involves some very tough political decisions – especially for developing countries that might have discovered reserves of fossil fuels that could potentially increase access to energy and improve the nation’s standard of living.

“NDC implementation means making the really hard decisions, and it is a difficult choice to keep those resources in the ground,” she says. "For developing and developed countries alike, there are...
vested interests, so we need to find ways to support the champions of tomorrow. We have the technologies we need to implement the NDCs, so I do feel it is political will that is still the standout challenge. Our job at Ricardo Energy & Environment is to help governments win those arguments internally and to provide them with the practical solutions for implementing their NDCs.”

The financial dimension

With public finances severely squeezed in almost every nation, finding the budget for climate action is increasingly difficult: as a result, the focus is shifting from state sources to private and corporate funders. “We need to get better at harnessing private-sector investment,” observes Holdaway. “We need to come up with financing propositions that are attractive to private investors, and that means building a bridge between the financial sector and climate policymaking – which traditionally speak two different languages.”

But while the political will is improving, notes Dodwell, finance and capacity will still be the real brakes on actually making things happen in the longer term. “The art, now, is how to develop investment pilots that can become business-as-usual models for funding projects at scale – models that you then can take to capital markets to get private-sector investment flowing into because they are perceived as the norm. Fossil-fuel investment would be seen as potentially higher risk because of the risk of it being stranded in assets such as coal-fired power stations which are moth-balled by the end of their lifetimes.”

The challenge now, he continues, is to use the available public finance to build the enabling conditions that allow people to view these new low-carbon opportunities as the less risky investment. These enabling conditions would embrace suitable legislation and capacity, experience of structuring deals and attracting investors into this kind of investment, and familiarity with the various instruments that can be used to de-risk such investment.

“Investing in low-carbon technologies in developing countries is still seen as a bit of an unknown,” concedes Dodwell. “What we now have to do is to demonstrate how to attract private-sector investment at scale – which is where the concept of GNiplus [see panel] comes in.

Is the outlook now brighter?

Both Ricardo specialists profess themselves more optimistic about the future than they were a year ago, before the Paris conference. “I’m definitely more optimistic,” says Chris Dodwell. “Countries are really rising to the challenge of implementation.”

Elaborating, Emelia Holdaway stresses the huge political support and political momentum internationally for the Paris Agreement. “That makes me feel positive. We now have unique conditions where the first worldwide climate treaty that everyone has agreed to has come into force: that has been 22 years of work, and we have that as a driver. At the same time we also have low oil prices, which means an additional driver especially for economies who depend on oil exports to diversify their energy mix, ideally towards low carbon energy sources.”

Low oil prices, especially for countries reliant on selling oil for their income, provide a clear prompt to examine whether they want to remain tied in to oil, or whether they should diversify their economic bases. “In the discussions I had at Paris and Marrakech, I saw countries speaking with a lot more ambition than I’d heard previously. In developing their NDCs, countries haven’t been told what to write in their plans – these are their own nationally determined pledges, and no one is telling them what commitments they should have. That changes the game a little, because this is a bottom-up movement, not as top-down as other attempts at international agreements were.”

The sheer scale of the challenge is not being underestimated by climate change policymakers: it is understood that implementation of the Paris Agreement will not be about tinkering around the edges, says Holdaway. “This is about paradigm shift. This is about decarbonizing our economic plans and decarbonizing our economies. To see more and more policymakers and leaders speaking in those terms, as happened in Marrakech, requires both realism and a can-do attitude. There’s everything to play for, and the signs are good.”

Climate-speak decoded: what the letters stand for

| UNFCCC | United Nations Framework Convention on Climate Change | The only international treaty on climate change, 194 nations have signed the Paris agreement and 116 parties have ratified the accord so far |
| COP | Conference of the Parties | Annual meetings bringing together all the parties involved in curbing climate change. Marrakech, COP22, was the 22nd |
| NDC | Nationally Determined Contributions | Countries decide for themselves the type and scale of climate mitigation and adaptation measures they plan to implement |
| CLICC | Country Level Impacts of Climate Change | International project to determine a common template for presenting the impacts of climate change on an individual country |
| CBIT | Capacity Building Initiative for Transparency | Part of the Paris Agreement, CBIT aims to strengthen the institutional and technical capacities of developing countries to meet the enhanced transparency requirements in the Agreement |
| MRV | Measurement, Reporting and Verification | Templates for the regular obligatory reporting of each country’s GHG emissions, enabling progress to be tracked |

In future editions of RQ we will be reporting in greater detail on Ricardo Energy & Environment’s initiatives relating to the broader issue of climate change.
Rapid urbanization and a strategy of economic diversification into non-oil sectors mean that the countries of the Gulf Co-operation Council now constitute a region of growing opportunity for Ricardo’s environmental and transport consulting businesses. Anthony Smith reports.
For many decades the oil and gas sectors have been the mainstay of the economy of the Gulf Co-operation Council (GCC) region. Buoyed by the strong export revenues that these sectors have generated, the GCC nations, comprising the Kingdom of Saudi Arabia, Kuwait, the United Arab Emirates (UAE), Qatar, Bahrain, and Oman, have enjoyed significant foreign exchange balances and comparatively low requirements for debt financing to cover public spending to bridge short-term fluctuations in energy export demand or prices.

In recent years GCC governments have boosted public sector employment and spending on infrastructure, health and education; this has sought to raise the standard of living of citizens and diversify their national economies away from an over-reliance upon oil and gas exports. Greater diversification, in its turn, seeks to reduce exposure to volatility and uncertainty in the global oil market, and also helps to create private sector jobs, increase productivity and sustainable growth and establish a non-oil economy that will be essential in the longer term when oil revenues start to decline.

Perhaps the most notable embodiment of this change of economic focus is Dubai, which over the past three decades has transformed itself through rapid, grand-scale development projects spanning everything from commerce and industry to public services, transportation and tourism. And where Dubai has led, others are following: major developments across the GCC area are exemplified by those associated with the 2022 World Cup to be hosted in Qatar. This is also fuelled by populations being concentrated largely in cities within the region, and the desire amongst governments to create world class living and working environments. The consequent desire to remain leading edge and innovative in development pervades throughout the region.

**Opportunities in transport**

While the Ricardo group has not traditionally been engaged in Middle Eastern markets, the company’s rail and environmental consultancies do have a history of involvement in this region, having been active in the area prior to their respective acquisitions by Ricardo. These two consultancy divisions are now stepping up their engagement in the Gulf region, recognizing the significant growth opportunities that it offers.

Mike Elliott is Middle East general manager for Ricardo Rail and has been based in Dubai for ten years. He has experienced the rapid expansion of its rail sector first-hand. “My original role here was in 2006 when I came out to work on the first phase of the Dubai Metro,” he says. “This was the first metro system to be constructed in the GCC region, and was from the outset very ambitious in terms of its technology level, the project delivery schedule, and the sheer scale of the development.”

The ambition of the Dubai Roads and Transport Authority (RTA) in this first metro system for the GCC region was impressive. The system’s Red Line opened in 2009, less than five years after the construction contract was placed, and the system was specified to a state-of-the-art standard from the outset. With modern rolling stock and platform screening throughout,
the system is completely driverless – indeed after completion of the Green Line, which began operation in 2011, it is to this day the world’s longest driverless metro system. It has been a phenomenal success for Dubai, too – so much so, that a contract has recently been awarded for a further 15 km extension to take the system length to 85 km. The upgrade will also increase service frequencies by reducing headway down to 2 minutes, and the rolling stock fleet will grow from 88 to 138 five-car trains.

“Safety assessment of this metro was just as rigorous as would be required for any modern mass transit system anywhere in the world,” continues Elliott. “The Dubai metro uses, for example, the same automatic train control system as used on around a quarter of the London Underground network.”

The successful launch of the Dubai Metro meant that, at the time, it held the title of the region’s only mass transport system. Very soon, Mike Elliott’s team began to secure crucial independent safety assessment roles for a series of metro and tram system projects across many other GCC states and cities. The first of these was Doha, with an ambitious project spurred by its development ambitions surrounding the award to Qatar of the 2022 World Cup. The system is scheduled to open its first 180 km phase in 2020, with a significant further expansion to follow in the second phase. “The Doha metro system is predominantly underground, thus minimizing surface-level disruption,” explains Elliott. “It’s a very significant undertaking, compared with London’s Crossrail, Europe’s largest construction project, which comprises 42 km of tunnels and is constructed using eight tunnel boring machines. The Doha metro used 21 tunnel boring machines across a system over twice the length of the London project.”

Ricardo Rail (subject to ongoing novation of the former LR Rail contracts) is also providing the independent safety assessment role for other significant projects such as the Riyadh metro – a project of the ArRiyadh Development Authority – construction of which commenced in April 2014 with completion planned for 2018. In addition to its involvement with new metro and tram systems the company is also providing the same role for the mainline freight system of Etihad Rail. This project is being developed in the UAE as part of the wider international GCC Railway project.

“London’s Crossrail, Europe’s largest construction project, which comprises 42 km of tunnels and is constructed using eight tunnel boring machines. The Doha metro used 21 tunnel boring machines across a system over twice the length of the London project.” Mike Elliott, Ricardo Rail, Middle East general manager

Again demonstrating the manner in which the GCC region is aiming to provide world-class technology from day one, the first phase of the Etihad Rail network is being equipped with both the latest European ERTMS signalling technology and US Electro-Motive Diesel locomotives. “In effect,” observes Elliott, “the first phase of Etihad Rail is demonstrating a hybrid of state-of-the-art European signalling and American heavy freight railway technology.”

Environmental consulting

While Ricardo Rail has been active in the Middle East for many years and has offices in multiple countries, Ricardo Energy & Environment is a comparative newcomer to the region. The environmental consultancy’s ambitions to grow internationally following its 2012 acquisition and merger into the Ricardo group were widely stated at the time.

But as Manjit Kahlon, the company’s
lead for the Middle East, explains, the genesis of its current phase of business development in the region was – initially, at least – entirely opportunistic: “Although we had some prior experience within AEA Technology (forerunner of Ricardo Energy & Environment) of running projects in the Middle East in the 1990s, and I and other colleagues had direct experience of working there, the region itself was not a particular target for us.

“The situation changed, however, in 2013 when we won a major air quality project for the city of Riyadh, from the ArRiyadh Development Authority. Across the first six months of the project the relationship developed to the point that we were contracted to deliver an expanded scope on the air quality project, as well as securing a further major contract with the Authority to help develop the future waste management and recycling strategy for the city.”

As with the metro and tram system projects of Ricardo Rail, the drivers for these environmental consulting opportunities were associated with the rapid urban development of the region’s major cities. Kahlon contends that there is a growing awareness of the importance of environmental issues as the region’s governments seek to diversify their national economies and at the same time provide their populations with a Western style and quality of living.

“Environmental protection has for some time lagged behind the more obvious and immediately visible trappings of a modern city-based consumer lifestyle,” he explains. “But with increasing urbanization come the challenges of poor air quality arising from transport and industry, as well as the need to tackle waste management and recycling. City authorities across the Middle East are increasingly recognizing the importance of environmental protection in ensuring the health and wellbeing of their citizens.”

Cultural factors
Doing business in the Middle East can be very different to the West, both in the direct relationship with the client as well as in the way in which projects are managed and delivered. One of the more immediately obvious differences is in the shorter project schedules that are typical. These arise from the comparatively simpler approval processes for public projects in this part of the world. While the lack of a more collegiate structure, with numerous checks and balances, contrasts with the process in Europe, the Middle Eastern approach does enable development projects, including those of major infrastructure, to be completed extremely quickly and efficiently. Perhaps the most distinctive cultural difference in transacting business in this region, however, is the investment in time and effort required to establish a relationship of trust. “It is often said that when you meet a potential new customer in business in the Middle East, your first three meetings will just be about them assessing you,” explains Kahlon. “Only on the fourth meeting and beyond do you move to really substantive discussions – and only then if you have been able to establish a relationship of trust.”

This focus on trust is in part a reflection of longstanding local business culture, but also in part a response to previous poor experience of consultants. 

Providing independent safety assessment for major transportation projects
Ricardo Rail has provided – or is in the process of delivering – the critical role of independent safety assessor for a range of major transportation projects in the Middle East including:

- Dubai Metro
- Dubai Tram
- Abu Dhabi Integrated Transport Network (metro and tram system)
- People mover system for Qatar Foundation Education City
- Doha Metro
- Lusail LRT, Qatar
- Long Distance passenger and freight railway (Qatar component of GCC Rail project)
- Riyadh Metro (6-line 176 km metro)
- Etihad Rail – freight railway network, UAE component of GCC Rail project
Many potential customers have stories of previously having been ripped off by consultants who have over-promised and under-delivered,” Kahlon continues. “A level of caution in double- and triple-checking credentials and qualifications, for example, is to be expected.”

Both Kahlon and Elliott also underscore the importance of being present in the region and of having regular face-to-face time with customers in order to manage projects effectively and gather information on potential future leads. “One of the lessons we have learned very well is that senior people have to be in the client’s eye,” explains Elliott. “Customers expect that a good proportion of work will be delivered in-territory. Technically there is no reason why much of the work couldn’t be done remotely, visiting to gather data and information and then feeding this to delivery teams elsewhere in the organization. However, this misses a critical opportunity to build trust through time spent with the client. Customers want to see you in an office in their territory and to build a strong relationship with you. Later on, the very same customers who expected in-territory working may be far more relaxed about where work is carried out for follow-up contracts, once they trust that we will be as good as our word in delivering.”

But there are further benefits to investing in the client relationship beyond managing the projects in hand. Regular contact is extremely effective in understanding the customer’s world and the motivations behind business and project decisions. This is something that can be extremely useful in managing projects effectively and profitably.

A further lesson to note is the significant effort required in developing local technical capacity within the client teams as part of project delivery. Such training and skill transfer ensures that a legacy remains that can sustain the changes and environmental improvements to which the region aspires.

Depressed oil prices – long-term potential

While there has been much discussion of the effect of the current depressed oil price upon the economies of the GCC nations, the appetite for significant economic diversification and development remains encouraging – and this will further boost the outlook for transportation and environmental consultancy services. “There has undoubtedly been a squeeze on infrastructure spending across the board,” explains Elliott. “But there is a

Helping the city of Riyadh with air quality and waste management

Two major projects carried out by Ricardo Energy & Environment for the ArRiyadh Development Authority commencing in 2013

Air Quality:
- Three-year project
- Stakeholder engagement, training & capacity building
- Air quality measurement, inventory and city-scale modelling
- IT solution for the management of air quality data
- Data reports and analysis & developing a consolidated evidence base
- Air quality index to inform stakeholders about air pollutant concentrations and health impacts
- E-mail alerts of major episodes
- Strategic decision making tool – pollution reduction strategies and facilitates cost and benefits analysis
- GIS mapping with flexible, scalable approach
- Expert analysis and advice – strategy development

Waste:
- Two-year project
- Stakeholder engagement & capacity building
- Policy and strategy development
- Technical assistance
- Implementation planning
- Capacity building and training
- Engaging and shaping industry involvement

The transportation systems being developed in the GCC region are truly world-class, with the latest signalling and vehicle technologies, including driverless trains.
“City authorities across the Middle East are increasingly recognizing the importance of environmental protection in ensuring the health and wellbeing of their citizens” Manjit Kahlon, Middle East lead, Ricardo Energy & Environment

recognition that some of the higher-ticket infrastructure spending still needs to go ahead as part of the major strategic development of the economies of the GCC region, rebalancing them away from hydrocarbon extraction in favour of other sectors. Many projects will happen at some stage, even if they are being delayed for the moment. Saudi Arabia has committed to having metros in Riyadh, Jeddah, Mecca, Medina and Dammam, with the Riyadh scheme viewed as a critical national project and, though some cost savings have been made, the project is progressing rapidly. The others, in my view, are merely being delayed rather than cancelled. There are strong socio-economic drivers for metro and tram projects too – something that might not be the case elsewhere in the world.

For the environmental consultancy, Kahlon believes that, in Saudi Arabia at least, the effect of the drop in oil price and the consequent squeezing of government revenues has been eclipsed – firstly by the pause caused by the death in January 2015 of the previous King, Abdullah bin Abdulaziz and subsequently by the administrative and government changes surrounding the accession by his half-brother, King Salman bin Abdulaziz al-Saud. “We always aim to develop an understanding of the context of the local situation and how this is affected by factors such as governmental changes, the effects of the oil price drop, and also the costs of the ongoing conflict in Yemen,” explains Kahlon. “Projects will get delayed and some may be terminated completely, but it is more a case of temporary delay and reappraisal of requirements, rather than a fundamental change of strategic intent.”

Developing local presence

Until recently, most Ricardo Energy & Environment projects in the Middle East have been carried out from the UK, but the consultancy has already moved to start the lengthy process of creating a permanent company registration in Saudi Arabia. This is essential if Ricardo is to be able to offer work as a lead contractor without needing to operate under the umbrella of a local partner.

With the exposure to many stakeholders gained through its Riyadh air quality and waste contracts, the team believes that there is significant opportunity for further growth: these contacts include the development authorities of the country’s other main cities as well as utilities and developers. And now that Ricardo Rail is a part of the group, further opportunities are also available – and Kahlon intends to leverage the already established Ricardo presence in the United Arab Emirates and Qatar.

Ricardo’s environmental consultancy is already carrying out work elsewhere in the Middle East, including donor-financed climate change mitigation consultancy in Egypt and environmental assessment of industrial processes in Palestine, but the potential of the GCC region is also significant and is one that is worth the investment of time and resource. Beyond the imperatives of helping to ensure clean air in the region’s cities and setting a more sustainable strategy for waste and recycling, Kahlon sees further opportunities by introducing Ricardo’s recently acquired water and energy consultancy services to the region.

For Ricardo Rail, which is already active and well established across the whole of the GCC region, the major strategic business development target is to develop transportation consulting opportunities beyond the third-party safety assessment area of expertise for which it has developed such an enviable reputation. Rolling stock, signalling and control systems, operations management and intelligent rail systems and technologies: all have potential for further business opportunities alongside those of independent safety assurance.

Despite the currently depressed oil price and the attendant pressure on public finances, development continues in the Gulf region at a pace that outstrips almost any international regional comparison. And for this reason, Ricardo continues to develop its local presence and capacity for delivery, as well as investing in the crucial long term relationships of trust that will help realize the ambitions of its customers.
It is often said that too many otherwise very promising technology-based ideas fail to reach market and achieve their true potential due to failures in the initial stages of the innovation process. In terms of NASA’s well-known model of Technology Readiness Levels (TRL), this is a problem that particularly affects the early stages of technology development, from concept to a robust prototype demonstration in a relevant environment (TRLs 1 through 6). The negative effects of this lack of understanding about the process of innovation are all too obvious for those immediately engaged in the endeavour of attempting to bring new concepts from the ideas stage to market maturity. But there is a much wider group of stakeholders who are also affected. For those seeking to invest in new technologies, for example, the level of technological uncertainty will translate into a risk premium to any backing advanced. A technological innovation might be disruptive to a particular landscape – so an ability to strategically view and scenario-test different models of market engagement may provide crucially needed confidence to proceed. Likewise, for those who are heavily invested in the technological status quo, an ability to envisage the likely future maturity of disruptive technologies can provide mission-critical information with which to inform the optimal timing of, for example, the strategy of a planned market retreat.

**Independent knowledge**

With its increasing active engagement in the processes of technology innovation across a wide range of industrial sectors throughout the world, Ricardo is well placed to apply its independent market and technical knowledge, tools, techniques and experience to any point in the development cycle.

Dr Penny Atkins leads Ricardo’s Advanced Technology Development (ATD) team, an organization which has been established to act as a focus for activities in this area. “In effect,” says

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Impartial expert advice is vital if high-potential innovations are to be brought successfully from concept into commercial reality. Clear guidance in steering projects from Technology Readiness Levels 1 to 6 can be especially valuable, as Anthony Smith reports.
NASA’s TRL framework

The Technology Readiness Level (TRL) framework is used by NASA to assess the maturity level of new technologies. At a TRL 1 level, scientific research is beginning and those results are being translated into future research and development. TRL 2 occurs once the basic principles have been studied and practical applications can be applied to those initial findings. At this stage there remains no experimental proof of concept for the technology.

At TRL 3, analytical and laboratory studies are likely to be required and a proof-of-concept model will be constructed. Beyond this, the technology advances to TRL 4 where multiple component pieces are tested with one another. TRL 5 is a continuation of TRL 4; however, a technology that is at 5 is identified as a breadboard technology and must undergo more rigorous testing than technology that is only at TRL 4. Simulations should be run in environments that are as close to realistic as possible. Once the testing of TRL 5 is complete, a technology may advance to TRL 6. A TRL 6 technology has a fully functional prototype or representational model.

TRL 7 technology requires that the working model or prototype be demonstrated in a space environment. TRL 8 technology has been tested and “flight qualified” and it’s ready for implementation into an already existing technology or technology system. Once a technology has been “flight proven” during a successful mission, it can be called TRL 9.

In recent years this NASA-originated framework has been adapted for non-flight environments and deployed across multiple industries and application sectors.

Atkins, “the ATD team provides an access point to Ricardo’s engineering teams and technical experts, wherever they are located and whatever their market and technology specializations. By understanding the clients’ needs in detail, we can configure exactly the right team to tackle the technology innovation challenge being faced. In this respect our mission can be summarized as providing services in the broad areas of technology strategy development, technology feasibility assessment, and technology demonstration exercises.”

The innovation processes being applied by the ATD team are very familiar from Ricardo’s in-house research projects, or from the product development programmes it carries out for the major OEMs. But, as Atkins explains, the customers for this new service are far more broad ranging: “We are as likely to be working with an investment fund manager as we are a technology start-up, or even an industry-wide body seeking to evaluate the potential of an entirely new mode of operations,” she reveals.

The following three case studies outline the breadth of focus of the ATD team and illustrate the diversity of its customer base. In the first, we describe a project carried out for a major South African fund manager with an interest in the likely future automotive demand for platinum group metals. Secondly, we present the case of technology start-up Yan Engines and its efforts to develop its O-Cycle engine concept and to move towards a physical prototype using bespoke simulation technology developed by Ricardo. Finally, we look at a study on the potential development and implementation of a multi-vector energy landscape, carried out for the UK Energy Systems Catapult.

Technology and market perspectives on the automotive demand for platinum group metals

Based in Cape Town, Coronation Fund Managers is one of the largest independent asset managers in South Africa. Platinum group metals represent an important sector for the country’s economy, and they make up a sizeable proportion of Coronation’s investable universe, with significant holdings in companies active in the sector.

Neill Young is a portfolio manager for Coronation. His responsibilities include analysing sector companies and predicting the future demand for platinum group metals.

“We already have a very good handle on the supply side of the industry,” he says, “but it is important for us to understand future demand too.” Our interest in investment terms is longer term – we are not talking month to month as much as five to ten years out.

“The automotive catalysis industry is a major driver for platinum group metal demand internationally,” continues Young, “so it’s important for us to understand this. With the happenings of last year – in particular, the ‘dieselgate’ saga – our attention was focused very sharply on the future of the diesel engine and the expectations in this respect of the major OEMs longer term.”

Young was not previously aware of Ricardo but had attended a conference in London in July 2015 at which a presentation was given by the company’s chief technology and innovation officer, Professor Neville Jackson. It was the technical depth and accessibility of the presentation that led Young to seek to commission a bespoke study on the future automotive demand for platinum from Ricardo’s Advanced Technology Development team.

In addition to requesting a thoroughgoing analysis of the automotive technology trends that would influence future platinum group metal demand for automotive catalysis, Coronation sought some in-depth guidance on the likely disruptive technologies that might emerge in the electrified vehicles sector. This information would provide valuable insights into the thinking underlying the headline technology roadmap projections contained in the Ricardo report. To this end, Young and his colleagues provided a list of technical questions in advance for the Ricardo team to address in their research.

The project team sought inputs from the engines, hybrid and electric systems and automotive catalysis teams from across Ricardo’s European and North American operations. The final report, running to 118 pages, explained the Ricardo
The extraction of platinum group metals represents an important part of the South African economy, and is hence extremely important to Coronation’s customers. The prediction mix of engines is very important to us at an immediate level,” explains Young, “as diesels use more platinum in their catalysis while gasoline engines use more palladium. Given that South Africa is a much bigger producer of the former, it’s crucial for us to understand this. Longer term, a further consideration for us is the pace of development of battery technology and how far this has to go before electric vehicles can substitute for a much larger part of the automotive market. We now have a better feel as to where this is heading.”

“The report was very comprehensive and has provided a useful reference for us,” he continues. “It was slightly more technical in some respects than we expected, but I don’t see that as a negative as it helped us to build our knowledge. It was very much what we were looking for.”

YAN Engines tasked Ricardo with developing a prototype version of a Ford EcoBoost 1.0-litre gasoline engine incorporating the D-Cycle piston technology. A basic model of the engine had already been created by YAN Engines using Ricardo’s WAVE software, but the project required the development of new simulation methods for the optimization of the piston motion at defined engine operating points. This included an approach to compare the simulation results of the baseline engine and the D-Cycle engine, as well as specifically-adapted simulation models for improved fuel consumption prediction. Using this bespoke toolset, sensitivity studies could be carried out on various base engine parameters to maximize the fuel-efficiency benefits of the D-Cycle concept.

“While engineering expertise and access to and understanding of the physics of its own proprietary CAE tools was a crucial consideration, location was also important: “We had recently opened an office in Brighton, so it was only natural that we wanted to start a working relationship with our esteemed neighbours in Shoreham!”

YAN Engines tasked Ricardo with providing simulation-based design support in the development of a prototype version of the timing and nature of the roll-out of disruptive technologies, and detailed responses were provided to Coronation’s specific questions.

“Ricardo has a strong reputation for its expertise in engine design and high quality delivery of work. It also has its own software tools – particularly WAVE and IGNITE. We identified that having a deep level of knowledge of these would benefit our project since we wanted to challenge some of the basic principles of conventional engine combustion models.”

But while engineering expertise and access to and understanding of the physics of its own proprietary CAE tools was a crucial consideration, location was also important: “We had recently opened an office in Brighton, so it was only natural that we wanted to start a working relationship with our esteemed neighbours in Shoreham!”

YAN Engines is a small technology company with offices both in Austin, Texas, and Brighton, UK. The company is focused on the development of its own proprietary high-efficiency engine concept that aims to provide significantly enhanced flexibility over the conventional four-stroke internal combustion engine architecture.

The differential stroke cycle piston (D-Cycle) concept relies on a split piston that completes the four engine strokes in a single crankshaft revolution, thus providing the opportunity to reduce the cyclic energy losses and improve combustion process efficiency. This is achieved via the use of a vertically split piston, with a lightweight crown and ring lands which can be moved independently of the main piston body to accomplish the lower stress functions of the induction and exhaust strokes. During more mechanically demanding compression and combustion strokes, the two parts of the piston are recombined, and power transmitted solely via the crankshaft. The D-Cycle concept thus achieves all four strokes of the piston within a single rotation of the crankshaft. More than this, it provides a much greater flexibility in improving efficiency, for example by reducing intake stroke volume to match the desired drive cycle demand with a long Atkinson expansion-to-compression ratio.

A veteran of engineering and management consulting, YAN Engines CEO Lu Yan approached the Ricardo Advanced Technology Development team for support with the simulation and refinement of this highly innovative engine concept. “Ricardo has a strong reputation for its expertise in engine design and high quality delivery of work. It also has its own software tools – particularly WAVE and IGNITE. We identified that having a deep level of knowledge of these would benefit our project since we wanted to challenge some of the basic principles of conventional engine combustion models.”

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“We learned a lot from the design study,” explains Yan. “It challenged a lot of our assumptions and delivered a lot of valuable information for our prototype build. Most importantly, it validated the fuel efficiency benefit that can be accomplished on a retrofit basis to a
production OEM engine.”

In addition to providing a clear technical direction for the next stage of prototype development, the project was useful to YAN Engines in its communications with existing and potential backers. “Once we complete and re-work the model based on dynamometer data, we will be able to show the correlation of the WAVE model with actual results,” says Yan. “Therefore, we believe that confidence in the performance and efficiency of future engines can be gained by investors on the basis of simulation tools. The knowledge of the Ricardo team in terms of the development process has been valuable to us to better scope future budgets, schedules, and teams, both for internal planning and investor meetings.”

While the initial demonstration of the D-Cycle concept has been based on the retrofit of the technology onto an OEM production engine to deliver increased fuel efficiency, Yan is far more ambitious when it comes to the idea’s longer-term potential: “Our D-Cycle piston technology can deliver a choice of different benefits: more torque or more efficiency by way of a new piston profile that can be changed within a given engine architecture. No longer will engines be designed around full displacement of the stroke, while sacrificing fuel efficiency for the drive cycle. Tomorrow, we will implement an engine with optimized piston profiles based on whatever is the intended use for the vehicle. Ricardo’s WAVE software and the capability to optimize the piston profile will be a key resource in this future.”

The Energy Systems Catapult therefore required completely independent and objective support in studying the potential requirements of a multi-vector energy future.

A project team was assembled, encompassing experts from across the Ricardo divisions – including the energy practice of Ricardo Energy & Environment. The objective of the first phase of the study was to build an understanding of the current status of multi-vector energy testing and demonstration tools and facilities in the UK, and to identify any gaps.

By comparing existing test facility capabilities with market trends and potential end-user needs, a number of gaps and opportunities were identified. One objective was to identify facilities with potential to offer or to be expanded to accommodate a multi-vector testing approach. Additionally, the team identified other UK organizations with extensive multi-vector energy facilities and capabilities that could be exploited, but which do not currently see energy as their primary function.

In the second phase of the study, carried out in early 2016, the team investigated the additional facilities identified in phase 1 and developed use cases and requirements for a potential future multi-vector testing facility. A total of six use cases were developed, based on the results of extensive stakeholder engagement. These ranged from developing a business case and commercial support for innovation, through to the demonstration of multi-vector energy systems and components, and effectively cross-mapped onto the levels of NASA’s TRL model.

Based on this work, the technical and non-technical requirements for each use case were identified, ranging from the physical assets and systems that the facility needs, to the human and commercial aspects of the facility.

“This was my first experience of working with Ricardo,” concludes Brown. “The team performed exactly as I would expect of a professional multi-disciplinary consulting company. They articulated the problem in detail before starting the work, and they delivered the results to me in a manner that was both informative and actionable. This work provides us with a very solid foundation for further study with a view to prototyping and evaluating such a multi-vector energy test and demonstration capability.”

A potential future multi-vector energy landscape for the UK

The Energy Systems Catapult is a leading technology and innovation centre set up to help the UK navigate the transformation of its energy system (comprising electricity, heat and combustible gases) and to capture the new commercial opportunities created. In mid-2015, the Catapult approached Ricardo with a view to supporting a study into the potential of developing a core test and demonstration competence in the multi-vector energy space within the UK.

“One of the key challenges for those active in looking at multi-vector energy systems is the ability to test new innovations,” explains Catapult head of innovation Eric Brown. “Our aim with this multi-phase project was to assess the potential for such a capability within the UK, based on a thorough analysis of existing facilities and development options.”

Energy systems are changing, whether by necessity, technology improvement or consumer needs. The ability to cope with energy flows in both directions, both upstream and downstream, can create major challenges in balancing supply and demand; this often results in infrastructure capital costs to upgrade for peak supply/demand capacity as well as the associated increased running costs for operation and maintenance. Additionally, the ability to integrate the energy supply and demand requirements of the electricity, transportation and heating sectors is increasing, giving rise to the potential for multi-vector approaches and the development of integrated energy systems.

Such innovations could potentially deliver significant economic, industrial and societal benefits, in terms of national energy efficiency, international technological leadership, and climate change mitigation. However, the scale and specialization are such that a much wider perspective is required than might be possible from any one commercial or private sector actor within the existing energy landscape.
More than 2000 engines were manufactured by Ricardo in the six months to the end of October 2016 – a higher total than achieved in any previous full year in the company’s history. The big rise was facilitated by the expansion of the advanced assembly plant at Ricardo’s Shoreham site, which was formally opened early this year, but the record figure included an extremely diverse range of state-of-the-art prototype engines constructed for numerous global clients.

Customers for engines produced by Ricardo in this record-breaking period included a total of 15 major automakers and engine suppliers. Production included everything from prototypes and pre-production units to niche-volume series production of high performance products; the units themselves ranged from single-cylinder engines used for research purposes through to V12s for marine and power generation. Cylinder bore sizes were everything up to around 200 mm, pressures ranged beyond 300 bar, and the production tally included both naturally aspirated and multi-stage boosted engines, as well as next-generation hybrid powertrain systems.

Despite the production of a record-breaking total of over 2000 engines in six months, the expansion of Ricardo’s advanced assembly plant and continued investment in its prototype engine build facilities mean that there is still considerable further capacity available to support the future prototype and niche production requirements of the company’s international client base.

“The record number of engines produced over the past six months shows that Ricardo has truly arrived as a manufacturer of advanced and high-performance powertrains,” commented Ricardo Performance Products managing director Mark Barge. “This is an operation that extends beyond Ricardo to the sophisticated supply chain that has seen us globally sourcing over three million components in just a little over five years.”

Wave Energy Prize

A significant milestone in the development of marine renewable energy in the United States was passed with the completion of the Wave Energy Prize project – a complex competition aimed at sparking innovation in wave energy conversion technologies. The Wave Energy Prize was administered by Ricardo under contract to the U.S. Department of Energy (DOE), and started in late 2014 with six months of planning followed by 20 months of public activity.

Ninety-two teams registered for the prize beginning in April 2015. Of these, 66 turned in technical submissions that were evaluated by a panel of judges to identify 20 official Qualified Teams in August, with the AquaHarmonics team (pictured) winning the $1.5 million grand prize.
Ultra-reliable railway points technology

A consortium led by Ricardo Rail is to develop the first installation of ‘Repoint’, a new ultra-high reliability railway point (switch) system designed by Loughborough University.

Repoint introduces the concept of using several actuators to operate the same points, meaning that in the event of a single failure the remaining actuators can continue to function safely. With this facility built into each unit, rail traffic can still pass and remedial maintenance can be scheduled without causing immediate disruption to rail services, thus increasing reliability and capacity on the railway.

Repoint also applies a unique ‘lift, hop and drop’ mechanism that eliminates the friction experienced by the slide chairs used in traditional point machines, resulting in faster operation and moving a switch in under half a second compared to four seconds for conventional designs. The development of Repoint originates from a request by the UK Department for Transport.

Safety-critical systems event

The final results of the Ricardo-led PICASSOS project will be presented at an end-of-project seminar event to be hosted at the British Motor Museum, Gaydon, Warwickshire, on 28 February 2017. PICASSOS’ task was to conceive and validate methods for the development of safe embedded software systems at an affordable price.

PICASSOS, which stands for Proving Integrity of Complex Automotive System of Systems, has been a three-year research initiative led by Ricardo together with partners Jaguar Land Rover, Johnson Matthey Battery Systems, YorkMetrix, D-RisQ and the universities of Oxford, Coventry and Warwick. The research initiative was part-funded by the UK’s Advanced Manufacturing Supply Chain Initiative (AMSD), and the project focused on the creation and testing of methods for the development of affordable, safe electronic systems, in compliance with ISO 26262.

The end-of-project seminar will focus upon the practical applications of Formal Methods (mathematically based techniques for the development of electronic systems) to the functional safety of automotive systems and beyond. Formal Methods offer the power of rigorous reasoning and proof, but are often little understood and consequently seen as more difficult to apply than can actually be the case.

Those attending the event will be able to learn in practical terms how they can improve safety and reliability by incorporating Formal Methods into their Model-Based Design workflows for system and software design. The seminar will aim to demystify formal verification and help to make it more accessible to engineers by showing how it can be harnessed practically and applied for the benefit of typical engineering processes.

Delegate places on the PICASSOS end-of-project Formal Methods seminar are free of charge, but strictly limited in number. Those wishing to attend should contact picassos@ricardo.com without delay.

Powertrain electrification research results revealed

Heavy duty vehicles, such as long-haul trucks, represent a significant challenge when it comes to reducing carbon dioxide (CO2) emissions. This subject has been the focus of the European Commission-supported ‘CORE’ project, a four-year research collaboration in which Ricardo has been working with project co-ordinator Volvo and a range of other industrial and academic partners, including Daimler, CRF and IA V.

In a presentation made at the Aachen Colloquium in October by Ricardo global technology director Dr Simon Edwards, the final results of the CORE project were revealed. The paper showed that the project team had achieved its stated targets in highlighting achievable pathways to CO2 reduction for future commercial vehicles. Taking into account the recalibration of a Euro V engine to Euro VI, vehicle simulations have demonstrated four different CORE powertrain concepts delivering CO2 reductions of between 11 and 18 percent compared to current production Euro VI vehicles.

The results of the project showed that the relative benefits of each of the technologies incorporated in the four power-train concepts depends upon the vehicle application and its duty cycle. Engine down-speeding, coupled with boosting system improvements and friction reduction, were seen to be beneficial in all cases. Similarly, aftertreatment technology improvement was consistently beneficial but at a relatively lower rate. The significance of the benefits of hybridization and whether the application of VVA is beneficial depend on engine type, vehicle and duty cycle, but hybridization particularly beneficial for medium-duty operation.
Ricardo has created and demonstrated an advanced and cost-effective motorcycle Automated Manual Transmission (AMT) concept that offers the comfort and convenience of automatic and semi-automatic operation, but with better-than-manual fuel efficiency.

With the exception of the ubiquitous CVTs of scooters and the specialist hydrostatic and Dual Clutch Transmissions (DCTs) used on some premium or specialist products, almost all motorcycles around the world are fitted with manual transmissions. These offer a comparatively low-cost solution, but one that is unable to deliver the convenience or comfort of automatic operation.

In addition to issues of packaging, weight and cost, most automatic transmission technologies available for use on two-wheelers come with a further significant drawback: poor efficiency. The simple fact is that from hydrostatics to DCTs, CVTs and conventional automotive-style planetary automatic transmissions, almost no automatic can match the manual for fuel efficiency.

However, as Ricardo’s AMT demonstrator bike – based on a BMW K1300S – has shown in rigorous testing, an advanced AMT implementation can be offered as an option to an existing manual product using exactly the same clutch and gearbox, manufactured on the same production line. Not only can this enable an option that provides riders with the comfort and convenience of an automatic, but in automatic mode it can actually exceed the efficiency of the manual.

Technical configuration

The Ricardo AMT demonstrator concept is based on the use of an unchanged manual gearbox from the base model, making it an ideal candidate for an add-on solution enabling manufacturers to offer a high quality automatic without significant manufacturing, supply chain or parts inventory costs. Clutch and gear actuation – in this case using the original clutch, slave cylinder and shift system – can be via electric motors and/or hydraulic actuation. A Ricardo AMT transmission control unit (TCU) integrates with the standard motorcycle’s ECU to provide complete control of pre-programmed ‘comfort’ and ‘sports’ modes; it also allows a semi-automatic mode via push buttons on the handlebars for up- and down-shifts.

In each case, automatic pull-away and ‘creep’ functions are controlled by the TCU and there is no clutch lever. Shift interrupt is possible in all automatic and semi-automatic modes but, as with the manual mode, this is only available within the permitted engine speed range for the selected ratio for reasons of safety and to protect the engine and transmission internals.

“We are particularly excited at the results we have obtained from our motorcycle AMT research,” commented Stefano Di Palma, AMT lead engineer for Ricardo Motorcycle. “We’ve demonstrated how an AMT solution can be provided as an adaptation of an existing manual transmission comparatively easily and with maximum component commonality. As such, it provides a cost-effective option that can be offered by manufacturers to give customers a dynamic riding solution with the comfort of an automatic but with no loss of performance or efficiency.

“In addition, the shift calibration can be developed to suit the particular requirements of bikes in very different sectors, for example a fast shift for a sports bike or a more relaxed gear change for a cruiser bike,” added Di Palma.

For motorcycle manufacturers, the Ricardo AMT offers the advantages in platform strategy and modularity, with the ability to offer an automatic and semi-automatic option at comparatively low cost in terms of development, parts count and inventory costs. For riders, it provides the comfort of an automatic bike – as well as one which in fully automatic mode can also be more efficient than even a manual transmission, without any loss in the riding style and fun that are so important to motorcyclists.
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