Interview: Margo T Oge
Former director of the US EPA Office of Transportation and Air Quality on climate change and the future

Ricardo’s first 100 years
A century of invention, from tank engines and diesel innovation to smart grids, premium scooters and supercars

Russian revolution
AvtoVaz turns to Ricardo for its first foray into plug-in hybrid design and development

Ricardo acquires PPA Energy to provide strategic management expertise across the complete power sector
Four things that helped create over 20 million ISUZU Diesel Engines Worldwide

We value what you value...Engines that have been tested over time and proven themselves in extreme conditions like Antarctica with temperatures of -80°C. Used in applications for their reliability and durability everyday. We understand your concerns about the environment and why advanced technologies matter to keep you going. With more than 300 North American Service Dealers to support you locally, we will continue to build what matters to you for the future.

Call now for an update on all the Tier 4 Finals ready today!

**4L Series**
- 15 - 49 kW
- U.S. EPA Tier 4 Final
- Displacement 2.2L
- 5 Year / 5000 hour warranty

**4J Series**
- 30 - 84 kW
- U.S. EPA Tier 4 Final
- Displacement 3.0L
- 5 Year / 5000 hour warranty

**4H Series**
- 70 - 140 kW
- U.S. EPA Tier 4 Final
- Displacement 5.2L
- 5 Year / 5000 hour warranty

**6W Series**
- 250 - 382 kW
- U.S. EPA Tier 4 Final
- Displacement 15.7L
- 5 Year / 5000 hour warranty

www.isuzuengines.com
Isuzu Motors America, LLC :: 46401 Commerce Center Drive, Plymouth MI 48170
734 582.9470
Ricardo Quarterly Review • Q1 2015

CONTENTS

NEWS
Industry news ..................04

FEATuRES
Leading the grid in expertise ..................12
Ricardo acquires Guildford-based PPA Energy to broaden its power industry strategic consultancy. Anthony Smith speaks to the key players in international energy intelligence

Russian Revolution ..........17
Best known for its Lada models, Russia’s AvtoVAZ turned to Ricardo for support with a plug-in hybrid vehicle project. Farah Alkhalisi hears about an 18-month programme encompassing the development and integration of control system software and creating and refining the demonstrator on site in Russia

Ricardo’s first 100 years ..................20
Founded as Engine Patents Ltd in 1915, the company today known as Ricardo plc this year celebrates a century of innovation – and begins looking forward to its next 100 years of visionary engineering. We trace Ricardo’s origins and its progress to today’s global success story

FEATURES
Leading the grid in expertise ..................12
Ricardo acquires Guildford-based PPA Energy to broaden its power industry strategic consultancy. Anthony Smith speaks to the key players in international energy intelligence

Russian Revolution ..........17
Best known for its Lada models, Russia’s AvtoVAZ turned to Ricardo for support with a plug-in hybrid vehicle project. Farah Alkhalisi hears about an 18-month programme encompassing the development and integration of control system software and creating and refining the demonstrator on site in Russia

Ricardo’s first 100 years ..................20
Founded as Engine Patents Ltd in 1915, the company today known as Ricardo plc this year celebrates a century of innovation – and begins looking forward to its next 100 years of visionary engineering. We trace Ricardo’s origins and its progress to today’s global success story

NEWS
Industry news ..................04
Geneva show: power and speed roar back; decision time on diesel; timetable to autonomous driving; solar to undercut gas and coal; megawatt supercar has no gearbox; Le Mans racer from Nissan fields front wheel drive

RQ viewpoint: Paris Climate Conference 2015 ...........07
Why all nations need to prepare for this key event, by Heather Haydock.

Ricardo news ..................24
Next-generation e-motor avoids use of rare metals, aerospace collaboration for lighter automobiles; hydrogen refuelling scheme; water sector co-operation

Q & A
Margo T Oge ..................08
The former director of transportation and air quality at the US EPA tells Tony Lewin about unblocking the impasse on Capitol Hill and developing the historic climate change deal with President Obama and the auto industry

FEATURES
Leading the grid in expertise ..................12
Ricardo acquires Guildford-based PPA Energy to broaden its power industry strategic consultancy. Anthony Smith speaks to the key players in international energy intelligence

Russian Revolution ..........17
Best known for its Lada models, Russia’s AvtoVAZ turned to Ricardo for support with a plug-in hybrid vehicle project. Farah Alkhalisi hears about an 18-month programme encompassing the development and integration of control system software and creating and refining the demonstrator on site in Russia

Ricardo’s first 100 years ..................20
Founded as Engine Patents Ltd in 1915, the company today known as Ricardo plc this year celebrates a century of innovation – and begins looking forward to its next 100 years of visionary engineering. We trace Ricardo’s origins and its progress to today’s global success story

NEWS
Industry news ..................04
Geneva show: power and speed roar back; decision time on diesel; timetable to autonomous driving; solar to undercut gas and coal; megawatt supercar has no gearbox; Le Mans racer from Nissan fields front wheel drive

RQ viewpoint: Paris Climate Conference 2015 ...........07
Why all nations need to prepare for this key event, by Heather Haydock.

Ricardo news ..................24
Next-generation e-motor avoids use of rare metals, aerospace collaboration for lighter automobiles; hydrogen refuelling scheme; water sector co-operation

Q & A
Margo T Oge ..................08
The former director of transportation and air quality at the US EPA tells Tony Lewin about unblocking the impasse on Capitol Hill and developing the historic climate change deal with President Obama and the auto industry

FEATURES
Leading the grid in expertise ..................12
Ricardo acquires Guildford-based PPA Energy to broaden its power industry strategic consultancy. Anthony Smith speaks to the key players in international energy intelligence

Russian Revolution ..........17
Best known for its Lada models, Russia’s AvtoVAZ turned to Ricardo for support with a plug-in hybrid vehicle project. Farah Alkhalisi hears about an 18-month programme encompassing the development and integration of control system software and creating and refining the demonstrator on site in Russia

Ricardo’s first 100 years ..................20
Founded as Engine Patents Ltd in 1915, the company today known as Ricardo plc this year celebrates a century of innovation – and begins looking forward to its next 100 years of visionary engineering. We trace Ricardo’s origins and its progress to today’s global success story

NEWS
Industry news ..................04
Geneva show: power and speed roar back; decision time on diesel; timetable to autonomous driving; solar to undercut gas and coal; megawatt supercar has no gearbox; Le Mans racer from Nissan fields front wheel drive

RQ viewpoint: Paris Climate Conference 2015 ...........07
Why all nations need to prepare for this key event, by Heather Haydock.

Ricardo news ..................24
Next-generation e-motor avoids use of rare metals, aerospace collaboration for lighter automobiles; hydrogen refuelling scheme; water sector co-operation

Q & A
Margo T Oge ..................08
The former director of transportation and air quality at the US EPA tells Tony Lewin about unblocking the impasse on Capitol Hill and developing the historic climate change deal with President Obama and the auto industry

FEATURES
Leading the grid in expertise ..................12
Ricardo acquires Guildford-based PPA Energy to broaden its power industry strategic consultancy. Anthony Smith speaks to the key players in international energy intelligence

Russian Revolution ..........17
Best known for its Lada models, Russia’s AvtoVAZ turned to Ricardo for support with a plug-in hybrid vehicle project. Farah Alkhalisi hears about an 18-month programme encompassing the development and integration of control system software and creating and refining the demonstrator on site in Russia

Ricardo’s first 100 years ..................20
Founded as Engine Patents Ltd in 1915, the company today known as Ricardo plc this year celebrates a century of innovation – and begins looking forward to its next 100 years of visionary engineering. We trace Ricardo’s origins and its progress to today’s global success story
Emboldened by the quickening north American market and the bottoming out of gloom in Europe, leading automakers roared back onto the Geneva show stage with a spectacular display of speed, power, glamour and extravagance. No fewer than 15 high-powered sports models made their debuts – something of a record – while smaller and more affordable machinery struggled to grab a share of the spotlight.

Only Kia, with its downsized three-cylinder seven-speed DCT driveline, Lexus with its Mini-sized premium 2+2 concept, and Nissan with its Micra-replacing Sway resisted the lust for power. Mitsubishi, too, drew attention with a mid-sized plug-in hybrid crossover prototype that could well replicate the surprise success of the larger Outlander plug-in hybrid SUV.

Headlining the heavy hitters in the booming millionaire’s track car club were the Aston Martin Vulcan, the McLaren 675LT and P1 GTR, the Porsche 911 GT3 RS, the Mercedes AMG GT3 and Lamborghini Aventador SV; knocking at the door were the Ferrari 488 GTB, Honda NSX, Lotus Evora 400 and Morgan Aero 8, all production models. Not yet in contention is the swoopy Ford GT – still a concept – yet outpowering all was Koenigsegg’s outrageous Regera, complete with a 1500 hp-plus hybrid drivetrain (see page 6).

Honda’s affordable Civic Type R, with 310 hp, and the competing Ford Focus RS with slightly more, represented comparative sanity but still served to set the pulses racing.

More intriguing, however, were the many strategic moves on display, or implied. Aston Martin approaching a more mainstream market with a high-riding electric coupé concept, the DBX; Bentley trying to steal Aston’s thunder with its EXP10 Speed 6 two-seat coupé and its unspecified hybrid powertrain; Audi and Mercedes bidding for a slice of Tesla’s action with plug-in-hybrid versions of the Q7, C Class and S Class.

And with both the Jaguar F-Pace crossover and the convertible Range Rover Evoque confirmed for production, Lexus toting a Mini and DS becoming a standalone marque, the crossover in brands, sizes, segments and identities gains momentum by the minute.

European automakers face diesel dilemma

After a year in which both London and Paris threatened to crack down on diesels and when half of Germany’s monitoring stations recorded breaches of EU NOx thresholds, two studies have proclaimed leading diesel car makers Renault, Peugeot and Citroën European CO2 champions.

Figures from AAA Data put Peugeot top, with a fleet average of just 110.3 g/km, while JATO Dynamics gives the lead to Renault, assisted by some 11,000 sales of electric models, at 108.4 g/km. JATO puts Peugeot second, at 109.4, followed by Citroën at 111.4. Toyota slipped to fourth, despite a hybrid take-up rate of 50 percent in its big-selling Auris range.

The Netherlands, Denmark and France continue to boast the lowest national CO2 emissions from newly-registered cars, at 106.8, 110.8 and 113.9 respectively, with crisis-hit Greece and Portugal also below 110. Outside the EU, electricity-mad Norway scores 110.4, while at the opposite end of the scale Germany and Poland, without any CO2 incentives, languish at around 132.

The results have prompted Brussels-based NGO Transport & Environment to renew its call for all countries to implement company car policies and vehicle purchase and taxation regimes promoting low-CO2 models.
Timetables to autonomous driving

The sudden importance of electronics in automobiles was demonstrated not only in the US in January, when the Las Vegas Consumer Electronics Show threatened to upstage the Detroit NAIAS for automaker announcements, but also at March’s Geneva show. Some of the Swiss venue’s thunder was stolen when top officials from Volvo, Nissan, Ford and BMW chose the concurrent Barcelona Mobile World Congress to make public their latest developments in the now all-important areas of connectivity, electric vehicle integration and, above all, autonomous driving.

It was from a Barcelona platform that Renault-Nissan CEO Carlos Ghosn chose to announce the Alliance’s timetable for the roll-out of autonomous drive. The first stage, he said, will come in 2016, with a feature that will allow cars to negotiate stop-and-go traffic without direct driver intervention. The second wave, in 2018, will include cars able to drive themselves on the highway, including changing lanes. The third wave will feature technology that permits the car to handle more complex city driving autonomously. In all these cases, Ghosn said, the driver will remain in control at the wheel and have the option to use the technology when appropriate. High-end Renault and Nissan cars would be the first to feature this technology, he noted.

Volkswagen has announced that it will place 100 self-driving cars in the hands of customers in the Gothenburg area in 2017: in this public pilot, the vehicles will cruise automatically on selected stretches of highway, mixing with everyday traffic. Audi showed its hand with a well-publicized driverless A7 driving almost 1,000 km from Silicon Valley in California to the CES in Las Vegas: a similar car also completed several laps of the Hockenheim GP circuit at racing speeds. Google, Sony and Apple have all intensified their interest in the automotive sector and CEOs such as Ghosn and VW head Martin Winterkorn have welcomed their engagement.

In the year that EU energy consumption fell to a 20-year low, a study by the Fraunhofer Institute for Solar Energy Systems has calculated that solar-generated power will be cheaper than coal and gas power in sun-rich southern Europe by 2025. Advanced solar systems will deliver power for between €0.04 and €0.06 per kWh compared with €0.05–€0.10 for new coal and gas power stations and €0.11 for nuclear.

Even so, said Fraunhofer, the cost of solar was penalized by up to 50 percent due to risk factors built in because of the regulatory uncertainty still hovering over renewables.

Overall, the EU still imports most of its energy, with France and the UK the only major consumers producing more than half domestically. Of the EU’s own energy generation, nuclear accounted for 29 percent in 2013, with under 25 percent coming from renewables. Germany has seen a fourfold increase in renewables since 2000, generating 157 TWh in 2014; Denmark generates almost 40 percent of its energy requirements from wind.

The UK, meanwhile, has given approval to what will become the world’s biggest offshore wind farm: the Dogger Bank Creyke Beck project off the Yorkshire coast will have two groups of 200 turbines together generating 2.4 GW.

In the year that EU energy consumption fell to a 20-year low, a study by the Fraunhofer Institute for Solar Energy Systems has calculated that solar-generated power will be cheaper than coal and gas power in sun-rich southern Europe by 2025. Advanced solar systems will deliver power for between €0.04 and €0.06 per kWh compared with €0.05–€0.10 for new coal and gas power stations and €0.11 for nuclear.

Even so, said Fraunhofer, the cost of solar was penalized by up to 50 percent due to risk factors built in because of the regulatory uncertainty still hovering over renewables.

Overall, the EU still imports most of its energy, with France and the UK the only major consumers producing more than half domestically. Of the EU’s own energy generation, nuclear accounted for 29 percent in 2013, with under 25 percent coming from renewables. Germany has seen a fourfold increase in renewables since 2000, generating 157 TWh in 2014; Denmark generates almost 40 percent of its energy requirements from wind.

The UK, meanwhile, has given approval to what will become the world’s biggest offshore wind farm: the Dogger Bank Creyke Beck project off the Yorkshire coast will have two groups of 200 turbines together generating 2.4 GW.

EU proposes road charging for trucks

Transport Commissioner Violeta Bulc has unveiled plans to develop road tolling for both cars and trucks across Europe. Under the scheme, which members could opt out of if preferred, drivers would be billed for the distance covered, irrespective of the time or duration of the trip.

At present, Poland, Germany and Austria charge trucks but not cars for the use of motorways, while France, Italy and the Iberian countries impose motorway tolls for all users. Germany is preparing to charge car drivers for Autobahn use, refundable against annual excise duty for German citizens.

New: the summer tyre for winter too

Michelin is promising something of a revolution in the normally quiet world of tyres. Its newly-announced CrossClimate tyre combines the advantages of both summer and winter tyres and will carry certification for both functions. The two technologies, previously believed to be incompatible, come together in a tyre which adapts to different climate conditions to offer short braking distances on dry roads, the topmost EU label for wet braking, and the 3-peak mountain snowflake symbol (3PMFS) to certify it for winter use in markets and regions where the fitment of winter tyres is mandatory during the cold season.

Bosch CEO: batteries to be cheaper...

Battery power will double in the next five years, with lithium ion systems set to reach energy densities of 280 Wh per kg, compared with today’s values of 115 Wh/kg. These are the predictions of Bosch CEO Volkmar Denner, who also forecast a halving of battery costs by 2020.

Ensuring these rapid advances will be the Lithium Energy and Power joint venture uniting Bosch, Mitsubishi Corporation and GS Yuasa, while V-Charge, a parallel venture between Volkswagen and Bosch, will allow autonomous vehicles to seek charging points independently of their owners, thus increasing their effective range.

Toyota still on top

With all the sales statistics collated for calendar year 2014, Toyota has retained its crown of the world’s top carmaker with 10.23 million cars and trucks sold. A hairsbreadth behind came the Volkswagen Group, breaking into eight figures for the first time with a final tally of 10.14 million. In third spot, just under the 10 million mark, came General Motors. Yet despite the impressive figures for the year and the stemming of the decline in European sales, both Toyota and VW caution against undue optimism.

EU agrees to e-call

Following many years of debate and negotiation, the European Parliament and the member states have reached agreement on the adoption of automated emergency calling systems for new cars. E-Call systems have been shown to halve emergency services’ response times following an accident, saving a crucial 10 minutes on average; they will become mandatory for new vehicle types from March 2018.
Tokyo's hydrogen offensive

Interest in hydrogen vehicles has spiked in Japan following a rush of orders for the hydrogen-fuelled Toyota Mirai and a test drive by Japanese prime minister Shinzo Abe. Having taken 1500 orders in January alone, Toyota is stepping up Mirai production to 700 cars this year, 2000 in 2016 and 3000 the following year. The initial expectation was for just 400 units this year.

Honda will not put its rival, the FCV (pictured above), on sale until 2016, though concept versions have been displayed at several international motor shows.

Tokyo is investing almost $400 million in the hydrogen infrastructure and customer purchase incentives in the run-up to its hosting of the 2020 Olympic Games, aiming to demonstrate hydrogen as a viable automotive fuel. Already, a combination of national and city-based incentives offer Tokyo residents a ¥3 million (€22,700) subsidy on the purchase of a hydrogen-powered car, almost three times the support given to buyers of electric models.

In Europe, Audi and Volkswagen have announced their readiness with hydrogen fuel cell power, with Audi having purchased a package of patents from Canadian fuel cell pioneer Ballard Power systems. At March’s Geneva show Liechtenstein-based startup Nano-Flowcell unveiled a different take on its fuel cell equivalent, a flow cell running on ionic liquids. The Quantino (pictured) is a compact smaller brother to last year’s luxurious Quant E and F and uses a 48-volt version of the cell, claiming a range of over 1000 km.

EU at last agrees to safer trucks

Safer, more streamlined and more fuel efficient trucks have finally been agreed by the European Union in a compromise deal that sees the new standards heavily delayed and purely voluntary in status.

The new rules will allow longer and more rounded cab designs for the vehicles, giving drivers a better all-round view so as to improve safety for pedestrians and cyclists; the parallel improvement in aerodynamics will, estimates campaign group Transport & Environment, boost fuel efficiency by 7 to 10 percent and save hauliers around €3000 per vehicle per year.

The European legislators had originally hoped to have the new designs on the road by 2017, but the proposals have been strongly resisted by truckmakers, who wanted implementation postponed until 2025 at the earliest. Under the compromise agreement the changes will take effect in 2022, though the exact sequence will depend on the Commission’s vehicle safety update scheduled for 2016.

Trucks make up 3 percent of vehicles on the EU’s roads but account for 25 percent of Europe’s transport-related emissions. The OECD’s International Transport Forum has forecast that freight emissions will rise by 286 percent by the middle of the century and overtake passenger cars as the biggest source of CO2 in the transport sector.
The eyes of the world are on the United Nations Framework Convention on Climate Change (UNFCCC) as the countdown progresses to the crucial negotiation meeting to be held in Paris in December 2015. The objective is to achieve a legally binding and universal agreement on climate change, from all the nations of the world. How can this be achieved?

The international community has agreed that an effective response to climate change must include major emitters from both developed and developing countries. In advance of the talks in Paris, countries have agreed to submit INDCs, or Intended Nationally Determined Contributions, but what are they?

In essence, an INDC is a statement from a country about the climate change mitigation activities it intends to undertake and the expected GHG emissions reductions that will result. In other words, it is their ‘contribution’ to global efforts to avoid dangerous climate change. Depending on the development status of countries, a mitigation contribution could take the form of an absolute GHG emissions reduction against a baseline year, a reduction in the economy’s GHG emissions intensity, a target for a specific sector or just a list of individual activities or projects. Some countries have successfully lobbied for INDCs to have an adaptation component, covering activities aimed at building resilience to future climate change. Countries will need to set out their emissions reduction aims, explain why they represent a deviation from ‘business as usual’ and justify why that represents a fair contribution to the global effort. Countries “in a position to do so” have been invited to submit their INDCs by March 2015 and other countries will be working hard to ensure their INDCs are submitted by September at the latest. However, many countries do not yet have the technical capability or capacity to create INDCs. And they need help - in particular to calculate their current and future emissions and to identify the most cost-effective options to reduce them.

The Intergovernmental Panel on Climate Change (IPCC) has explained the need for a global emissions pathway consistent with its maximum 2°C global warming target, and there is a widespread consensus that if we delay action much longer, the situation may become unrecoverable.

A key challenge will be to provide targeted help and support so countries feel they can deliver the reductions set out in their INDCs – to make it something that they feel is within their grasp.

The key question is this: will INDCs deliver, or help deliver, the global emissions reductions needed to put us on a pathway to avoid dangerous climate change? The answer to the question is ‘in part’. We will need countries and governments to commit firmly to mitigation. A key challenge will be to provide targeted help and support so countries feel they can deliver the reductions set out in their INDCs – to make it something that they feel is within their grasp.

Ricardo-AEA is already supporting a number of countries on this vital work and is becoming the consultant of choice in helping to make this challenge ‘do-able’. This is because our staff have unique experience in this area and, importantly, because our approach is to help countries take ownership of these decisions. We do this by building sustainable local capacity, institutionalising the necessary processes to reliably and repeatedly fulfil the climate goals they have committed to, and giving them the confidence to move forward in contributing to the global effort to avoid dangerous climate change.
Have you spent your entire career in drawing up legislation? What was your original inspiration?
I have spent 32 years in the environmental field, but I have to admit that when I came as a chemical engineer to the EPA in 1980 my first daughter had recently been born and I did not want to travel much – so the EPA was ideal. It became a career that I really enjoyed – it has been good waking up every morning and knowing that you’re making a big difference.

Which would you consider the landmark achievements facilitated by you?
That’s a tough question, because you love all your children just as much, but there are probably two overall efforts that I undertook when I was at the Office of Transportation and Air Quality that are landmark achievements. The first one is our programme to reduce emissions from diesel engines – cars, trucks, vessels, locomotives, marine engines. It was a big effort, but it wasn’t supported by the truck engine companies or the oil companies. Yet it became one of our most successful programmes and collectively, all the diesel reductions will save 40,000 premature deaths a year.

The second one, clearly, is working under President Obama to undertake the first ever climate action in the US – the programme to reduce greenhouse gas (GHG) emissions and improve fuel efficiency for cars, running from 2012 to 2025.

What were key decisions that enabled these to happen?
The Supreme Court ruling in 2007? There was a long history leading up to these decisions. Climate science in the US goes all the way back to the Reagan era, but the impetus for the first climate action stems from 1999 when a petition from a number of environmental groups in the US asked the EPA to reduce greenhouse gas emissions from new cars and light trucks as part of the Clean Air Act; from then on we saw environmental groups join forces with a number of proactive States to push for measures, but under President Bush the EPA denied the petition and it went all the way to the Supreme Court. The Supreme Court ruling of 2007 was clearly one of the key drivers for the actions we took under President Obama.

Also, California State Senator Fran Pavley has been important in developing State laws enabling Californian authorities to move forward to regulate GHG emissions for cars. Under President Bush the administration was not really serious about climate change but in the EPA we did develop strong technical and economic analyses of the costs of reducing greenhouse gases; in 2008 the auto industry almost collapsed. When the Obama administration came in in 2009 they really looked at climate change in a totally different way. In only his second week in office, President Obama brought a number of us together in his office to give us his support to move forward – that was a big factor.

The EPA was battled at every turn for 40 years with court actions and undermining from Congress. Why is everyone now suddenly in agreement?
The momentum to cut the historic climate action deal came because it was the perfect storm. One driving factor was Obama’s determination to take action on climate change: in any case, California and several other states, representing about 50 percent of car sales in the US, would have moved forward on their own, and after the 2008 crisis and high fuel prices the automakers had all realised they did not have the fuel efficient cars the consumers were looking for. And the idea of offering the car companies one national programme was appealing – they could meet the California requirements, the EPA requirements under the Clean Air Act, and also the Department of Transportation requirements for fuel economy. That helped bring us together for this historic deal in 2012.
“The momentum to cut the historic climate action deal came because it was the perfect storm. One driving factor was Obama’s determination to take action on climate change”
Has the battle now been won? Could it all resurface under a future administration?

For cars, perhaps yes: we have a programme that will double fuel economy by 2025 and reduce GHG emissions from new cars by 50 percent. But it’s not a done deal. The reason I’m saying that is that the 2025 standards require the federal regulators to conduct a mid-term review in 2018 of all the factors affecting the 2025 standards. The understanding is that if the factors don’t play out, there may be some changes to the 2025 standards. With gasoline prices now falling, we have seen suggestions from certain OEMs that the 2025 standards may not be appropriate: I don’t think [those moves] will be successful, because gasoline prices are not going to stay low. We should not forget that we are not just regulating for fuel economy but also for climate change: we’re looking to a future where it is going to be zero oil, and forward-thinking companies will continue to invest in low-carbon technology.

In choosing a CO2-focused strategy for 2025, did you look at the European experience?

Yes we did. We evaluated very carefully what the Europeans were doing [with their weight-based system] and we decided that the most effective strategy to reduce greenhouse gases was to encourage weight reduction across the board. It helps all powertrains: if you have a lighter electric vehicle, it will help sizing that battery, and it’s the same for an ICE. So we chose to go in a different direction and regulate cars and light trucks based on their footprint rather than their weight. You don’t want to encourage people to build heavier cars.

Will every automaker have to include electric vehicles in order to meet the 2025 standards?

No. When we developed the 2025 standards we had made certain assumptions for each OEM, based on their confidential business plans. The 2025 standard will be met through the use of improved internal combustion engines: the requirement for strong hybrids and electric vehicles is estimated at between 1 and 3 percent. What is amazing is that more can be done to improve the ICE beyond what we need for 2025.

How much weight loss were you assuming in these calculations?

We were assuming a weight reduction of just 10 percent, but we know now that car companies are reducing the weight much more for certain models.

If you were still in post, what would your vision for post 2025 be?

We need to go back to what the science tells us about the efforts that need to be taken to address climate change. What we know is that we need to keep the temperature rise below 2 degrees if we are to avoid the most catastrophic impacts of climate change. In my book I try to translate this into what it means for the US and for the car fleet. The scientists are calling for 80 percent reduction in 2050 from 2005 levels. To limit the worst effects of climate change by mid century, all cars need to be at 180 miles per gallon and emit zero carbon pollution. These would have to be electric or hydrogen cars with renewable sources of energy. We’re [clearly] not going to have that with the entire fleet in 2050, but what should happen is that the US continues to see an annual improvement of 5 percent from 2026 to 2050. If we did that, we would have new cars in the fleet capable of 177 or 180 mpg – in other words, basically electric. But even if we managed that, we would still fall short of what it would take for the car industry in the US to meet the 80 percent reduction requirement. In my view, the gap will be met with low-carbon fuels like cellulosics.

Are there any further areas of concern that you would regulate if you had the power?

If we are staying in the area of climate change, in the US about 60 percent of the GHG emissions from the transportation sector come from passenger cars and 20 percent from the freight sector – heavy duty trucks. So trucks are an important target, and under President Obama, while I was still at the EPA, we took the first regulatory steps to reduce emissions from commercial trucks. The Administration is proceeding with a second effort
to reduce emissions from freight – unfortunately, Europe is not doing the same, because at the end of the day you want to see cars and trucks as global products with platforms that are harmonised across continents. In the US we are regulating greenhouse gas emissions for trucks, beginning in 2014, so this is the first year we will see more efficient trucks on our roads. The Administration is looking at taking further steps after 2018, and my former office is in the process of setting the standards now.

**What about aircraft emissions?**

This is the third sector I had in mind. Aircraft are about 10 percent of the transportation sector GHG inventory, so they need to be brought in to a regulatory framework. But given the international nature of air travel, you need to have an international effort: Europe has been more proactive in this area, but in the US we have not been as proactive as we should have been as our airline industry does not support strong GHG standards. But before I left the Office we had a legal action against the EPA from a number of environmental organisations to regulate emissions from aircraft. That case is pending in court, so potentially that court could have a big say, as in 2007, on how to proceed on aircraft. The court decision could [in effect] direct the EPA to regulate emissions from aircraft.

**Will the US have weaned itself off fossil fuels by the end of this century?**

My vision is that if we are to avoid the biggest impacts of climate change, not just the US but all countries that have a major role to play when it comes to transportation, must continue to take actions to reduce their emissions. Hopefully, by 2050 this will bring us new cars in major markets such as the US, Europe and China that are all powered by renewable sources – electric and hydrogen powertrains. Clearly, by the end of the century you would want all transport to be zero carbon. It’s a Herculean effort, but it can happen, we know how to do it and we can do it. It will create innovation, it will create prosperity and it will protect our climate. In the US it will take regulatory effort beyond 2025, and we must make sure we don’t see a gap of ten years when we don’t act.

**You are on the board of Delta Wing Technologies Inc. What do you hope to achieve there, and do you see the company as a game-changer like Tesla?**

The Delta Wing is an exciting very efficient race car, the size of a Sonic but capable of 58 mpg with a combustion engine. So when you incorporate an electric powertrain it could be pretty powerful: the architecture is very aerodynamic and we use lightweight materials. We hope to work with OEMs in the US or other countries to develop the design as a road car – it could be a disruptive force like Tesla.

Companies like Tesla and Google are threatening the established OEMs, and their continuing efforts will be significant in bringing us forward to a new generation of vehicles. Cars in the future will be more like your cellphone – they will provide more activities than just driving you from A to Z. With autonomous cars, mobility in the future will be very different to how you and I remember it.
LEADING THE GRID
Formed eighteen years ago, PPA Energy is highly unusual for a small technical consulting organization. Its customer list reads like a world atlas and ranges from the highly sophisticated energy markets of the UK and Europe to developing and rapidly industrializing nations across Africa, South America and Asia. Much more than simply a provider of engineering and technological expertise, PPA’s business model is summed up succinctly by its former CEO, and now practice director, Neil Pinto as “a niche power industry management consultancy straddling the domains of engineering, strategic management and commercial advice.”

But while the physics of electrical power generation, distribution and supply are clearly the same the world over, aren’t the challenges fundamentally different? No, they are not, says Pinto: “the principles of economic efficiency are something that are common and equally important to all parts of the world. While the factors affecting national strategy in terms of generating mix and the technologies applied to optimize grids...
and distribution networks will depend on a nation’s own imperatives, the technology and operational tools are broadly the same.”

**Smart grids – optimizing system efficiency**

In the mature markets such as the UK, a key challenge for government and private-sector generators and distribution companies is in optimizing efficiency. As in many industrialized countries, the UK’s power network evolved from a number of local authority and private sector operators providing for the needs of individual towns, cities and conurbations. Nationalization of these operators in 1947 enabled the development of a national grid infrastructure over the subsequent decades, something which transformed the efficiency of the system. Particularly since the industry’s privatisation in the early 1990s, the focus has been on achieving ever higher levels of efficiency from these existing distribution systems.

As such, PPA’s consulting activity in the UK tends to concentrate, for example, on efforts to equalize flows down feeders in order to minimize losses, and using telemetry [in the form of smart grid technologies] to improve network level control. “By developing an awareness of what’s going on across the network,” Pinto explains, “we can detect incipient faults and form a better understanding of network behaviour at any instant, allowing us to get better use and efficiency out of it.”

The focus of PPA on smart grid technology was highlighted in a recent collaboration with Ricardo-AEA on the development of an Energy Data Integration System (EDIS) in a project part-funded by Innovate UK. Now, following the acquisition, PPA forms the nucleus of Ricardo-AEA’s power industry consulting practice. This project, which was announced just a month prior to PPA joining Ricardo, will build and evaluate a ‘prototype data platform’ for cities to enable the modelling of energy demand and savings opportunities from an individual building level right through to the city-wide scale. Working with Coventry City Council, SmartKlub, and Cambridge Architectural Research, the Ricardo-AEA led partnership will deliver a series of case studies based on the needs of the city of Coventry to demonstrate the scope of EDIS.

**The demands of developing nations**

Rather than optimizing aspects of the performance and operation of existing systems, the demands on PPA services from developing nations tend to be focused more closely on guiding the overall evolution of the electrical generation and distribution infrastructure, in order to meet national socio-economic objectives.

In Sierra Leone the company is in the process of completing work for the Ministry of Energy, advising on how the country should meet some of the huge challenges it faces in improving the quality of electricity supply. The country suffers severe constraints on its generation capacity, and the distribution system is in a comparatively poor state. These infrastructural challenges are compounded by the ongoing Ebola crisis and the fact that Sierra Leone was the subject of a bitter insurgency until around 2000. PPA was engaged in order to advise on the formulation of future public policy and priorities for the power sector.

“For a country such as Sierra Leone, we can help by making estimates based on analysis of the evolving power requirements over, say, a ten year planning horizon,” explains Pinto. “We can then consider what generation mix is required to meet this, where should it be located, how should we interconnect the generators with the distribution grid, how can we expand and develop the distribution system, how should we be electrifying new areas, and what the
overall costs will be. Crucially, we need to establish, based on the scenarios developed, what the tariffs should be – in effect, how much should we charge customers, what are the affordability issues and other socio-economic factors to be considered.”

Where PPA distinguishes itself from its competition, Pinto emphasises, is in the fact that it can carry out a broad-ranging study such as this with a deep knowledge of each domain: “We have the necessary engineering and technology skills, and we also need to have expertise in financial modelling, economic analysis, and policy formulation. But if it is to provide genuinely useful guidance to the client country, all of this must be grounded on real engineering understanding.”

**Challenge and opportunity of renewables**

While much political, media and power industry focus on renewable energy in developed nations is on the development of wind energy resources, Pinto views hydroelectric power as being of far greater significance globally: “Within the developing nation context, hydropower offers a huge opportunity to reduce or remove the reliance on fossil fuel-based generation – but it is very expensive in terms of capital costs.”

PPA supported the first private hydroelectric power project in Uganda, a development sponsored by the Aga Khan foundation – where the company completed due diligence on behalf of the World Bank. PPA has also carried out similar projects in other nations including Guyana, South America.

While there are clear benefits to the development of renewable energy, Pinto contends that projects need to be economically and financially justifiable. The fact that the price of carbon has collapsed and that fossil fuel prices are currently low does not help the case for renewables, but against this there have been some significant reductions in costs, too, particularly for solar photovoltaics. However, the particular attraction of hydroelectric power, where geopolitical issues allow for its development, is that it is able to contribute to a nation or region’s grid base load in a manner that intermittent sources cannot. As hydroelectric generation is based on river flows and rainfall measured in most cases over months and seasons rather than in hours or days, it affords a level of predictability that can enable the strategic planning of grid-scale resources. In comparison, wind energy is clearly weather dependent and even in equatorial countries solar arrays clearly cannot generate in the hours of darkness. With maximum demand in many nations falling during an evening peak period, and in the absence of any practical and cheap means of large scale energy storage, the potential for these more intermittent sources to displace conventional or nuclear capacity is limited. “It’s not particularly helpful to compare the direct cost of each kilowatt hour generated by a wind turbine with that of...”

**China’s Three Gorges Dam (main picture) is the world’s largest hydropower project. The redundant cooling towers of Soweto’s former Orlando power station (above) are in stark contrast to the developing transnational network integration initiatives such as the Southern African Power Pool**

**PPA Energy services in summary**

- Low carbon and sustainability
- Energy regulation
- Power sector planning
- Smart grids
- Private investor services
- Capacity building and training

“PPA is a niche power industry management consultancy straddling the domains of engineering, strategic management and commercial advice”

Neil Pinto, PPA Practice Director
a nuclear, coal-fired or gas turbine power station," explains Pinto. "Instead, your costings have to be across the entire fleet for each scenario of mix between the different types of renewable and conventional generators. Only in this way can you economically justify the contribution of a given level of renewables. This requires some very complex and sophisticated system-level modelling and simulation in order to do that analysis.

In practical terms, will it ever be possible to completely decarbonise power supplies? Pinto feels that there is no clear-cut answer to that question, and this explains why different national governments have widely disparate views. "Without doubt we need to reduce our carbon emissions globally, but how are we going to achieve that? Within the context of a sophisticated industrial economy there is clearly a role for renewables, but that role has to be understood and economically justified. Nuclear is an option for complementary base load alongside hydropower where conditions permit, with distribution-level inputs from intermittent renewables facilitates through smart grid technologies."

Transnational network integration
Squaring the circle of how to make renewables work effectively as part of the generating mix is something that Pinto suggests may be enabled through the integration of networks across national boundaries. "The segmentation of countries providing all of their own requirements is clearly sub-optimal. If you look back to when the power industry was being developed in the UK, it was initially done on the basis of individual towns meeting their own requirements, which was sub-optimal. If you look back to when the power industry was being developed in the UK, it was initially done on the basis of individual towns meeting their own requirements, which was something that we came away from in order to realize higher levels of network efficiency. The same is now true of many national networks, where the benefits of cross-border interconnections are clear. We have had this here in Europe for some time now, but we are seeing more interconnectors planned both here and amongst developing nations."

PPA has been actively engaged in the development of the Southern African Power Pool [see p14], which aims to provide reliable and economical electricity supply from Cape Town to as far north as Angola, the Democratic Republic of the Congo, and Tanzania. To the north east, the countries of East Africa are preparing a similar initiative with a hydroelectric power generation hub planned in Ethiopia, while in West Africa and also in the Mekong valley of South East Asia further power pools are also under development. "These much broader trans-national networks will enable a much higher level of risk and reward sharing than would be possible at smaller scale," explains Pinto. "This in turn will open the way to much higher network efficiencies and help to realize the potential of renewable resources."

Future potential
Pinto believes that the timing of PPA’s integration with Ricardo is extremely prescient. The move provides for a significant extension of Ricardo-AEA’s international customer base while offering opportunities for synergistic growth of the newly combined power industries practice focused on PPA, while also capitalising on the wider Ricardo group’s expertise on renewable and conventional power generation systems and devices. "Since becoming part of Ricardo-AEA we have identified a wide range of opportunities where our collective skills might be deployed. Previously we might have used external sub-contractors or decided not to go for these prospects, but we are now collaborating on potential opportunities including economic elements of smart grids, renewable energy monitoring tools, national renewable energy strategies, climate finance and renewable investment plans. We are also exploring innovative engineering solutions with Ricardo."
Togliatti is Russia’s historic automotive heartland: traditionally home to high-volume car production, but under serious pressure in more recent years to modernize both its manufacturing practices and the vehicles it builds. Local car-maker AvtoVAZ, Russia’s largest, has been undergoing a restructuring: now owned in a joint venture in which the Renault-Nissan Alliance holds a majority stake, it is building Renault, Nissan and Datsun-branded vehicles on its production lines as well as its indigenous Ladas. And as it embraces the global automaking agenda, this Russian OEM has also been experimenting with electrification.

The AvtoVAZ hybrid vehicle demonstrator programme, funded by a grant from the federal Russian government, called for the development of four functioning plug-in hybrid prototypes based on the Lada Granta compact car. Three of these feature AvtoVAZ’s own engines: a gasoline/CNG dual-fuelled 1.6 and a naturally-aspirated gasoline 1.4; the fourth engine is an all-new turbocharged gasoline 1.4-litre, being developed in a separate and still-ongoing programme. Targets were set for CO₂ emissions, alongside the requirement for all the engines to comply with the Euro V legislation.

“The work we were doing was mainly the development of an algorithm to control the hybrid system. We also worked on interfaces to the engine and transmission control units, to control those as needed during the transitions between the various hybrid modes,” explains Chris Marshall, chief engineer.
control & electronics. “And generally, we worked to meet the vehicle performance targets, also to advise AvtoVAZ on the electrical system design, and some of their Russian suppliers on the design of the high-voltage components, the clarification of requirements, component-sizing and other issues.”

Specifications and supply-chain

Marshall’s team – led from Ricardo’s Technical Centre in Cambridge, UK, though drawing upon the knowledge of colleagues at the centres in Shoreham, Leamington Spa and Prague – had a new collaborative experience in that all the suppliers of the high-voltage components were Russian, including Itelma, maker of the engine control unit, and NAMI, a research institute which developed high-voltage components including the electric motor, the lithium-ion battery and the motor-controller. The automated manual transmission (AMT) was an AvtoVAZ unit incorporating electronic shift actuators and control software from Germany’s ZF.

“Basically, we defined the requirements of how the hybrid system was to operate, and any modifications which were needed to the engine control unit and the transmission control interface unit to make them operate with the new hybrid system,” says Marshall. “Itelma and ZF wrote the updated software for those modules, but we wrote the control software for the hybrid system ourselves, from scratch, and that was run on the Ricardo R-Cube rapid prototyping control unit.”

The architecture selected by AvtoVAZ was a parallel hybrid concept, where both the engine and the electric motor can drive the wheels at the same time. One of the key challenges in the first half of the project was integrating the AMT, on which AvtoVAZ had mounted the electric motor, explains engineer Daniel Chambers. “Whilst the transmission control unit was a production part, there had to be some modifications to make it work in the hybrid modes. For example, you want to keep the clutch open in electric-only mode, because you don’t want the engine connected to the powertrain in that mode. “ZF added a CAN gateway to modify the signals going to the transmission controller, and in our role as systems integrator we had to define the overall strategy and the signals specification, and make these extra modes and mode changes work; one example is the transition from electric vehicle mode to parallel hybrid mode. The wheels are turning, the electric motor’s driving the car, you have to start the engine, then you have to bring the engine to the correct speed and then you have to close the clutch – and the driver has to sense all this as little as possible. It’s a matter of making sure the engine speed is controlled accurately, sequencing these events and managing the different modules around the car so that they’re all working together smoothly.”

Managing the modes

The operating strategy was based on the assumptions that most journeys undertaken by such a compact plug-in hybrid would be short, and that it would be cheaper to charge the battery by plugging the car into the grid than to burn fuel. The key features of the strategy were therefore to prioritize the use of electric power where possible [at speeds of up to 60-70 km/h and under gentle acceleration] in a charge depleton mode, followed by a charge-sustaining mode where the focus is on maintaining the battery state-of-charge and on maximizing fuel economy.

“You’re aiming at an electric-only range that’s within a normal commuting distance, so 25 km is acceptable,” says Chambers. “And the standard way to operate a PHEV is to deplete the battery: assume you start with a full battery, because most people plug in overnight, deplete it to a level of around 30 percent, and then sustain that level within a margin of about 10 percent. We implemented that kind of a strategy, which means that, as long as you’re not driving particularly fast, you can drive mostly in electric-only mode with the engine turned off. And then once the battery gets to this lower level, you then operate with a combination of the electric machine and the engine, working together.

“Even when you’re in the charge sustaining mode with both the engine and the electric machine operating, you still achieve lower emissions and lower

<table>
<thead>
<tr>
<th>Hybrid architecture</th>
<th>Plug-in Parallel</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mass (kg)</strong></td>
<td>1360</td>
</tr>
<tr>
<td><strong>Top Speed (kph)</strong></td>
<td>&gt;180</td>
</tr>
<tr>
<td><strong>CO2 emissions target (g/km)</strong></td>
<td>115</td>
</tr>
<tr>
<td><strong>Engine</strong></td>
<td>1.61 CNG/gasoline</td>
</tr>
<tr>
<td><strong>Transmission</strong></td>
<td>4 speed AMT</td>
</tr>
<tr>
<td><strong>E-machine peak power (kW)</strong></td>
<td>30 (30 seconds)</td>
</tr>
<tr>
<td><strong>E-machine continuous power (kW)</strong></td>
<td>10</td>
</tr>
<tr>
<td><strong>E-machine cooling</strong></td>
<td>Water</td>
</tr>
<tr>
<td><strong>Battery chemistry</strong></td>
<td>Li-ion</td>
</tr>
<tr>
<td><strong>Battery cooling</strong></td>
<td>Air</td>
</tr>
<tr>
<td><strong>Nominal battery voltage</strong></td>
<td>289</td>
</tr>
<tr>
<td><strong>Nominal Battery Capacity (kWh)</strong></td>
<td>4.35</td>
</tr>
<tr>
<td><strong>DC/DC converter output current (A)</strong></td>
<td>120</td>
</tr>
<tr>
<td><strong>Charger (V AC)</strong></td>
<td>220</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CO2 results achieved</th>
<th>1.6 gasoline</th>
<th>1.6 CNG</th>
<th>1.4 T</th>
<th>1.4 N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Base</strong></td>
<td>155g/km</td>
<td>145g/km</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Hybrid</strong></td>
<td>96.6g/km</td>
<td>89.68g/km</td>
<td>90.06g/km</td>
<td>83.58g/km</td>
</tr>
</tbody>
</table>
fuel consumption. That’s also the mode in which you attempt to optimize the operating torque of the engine, push it towards its most favourable point on the fuel consumption map at all times. You can do this because you have the electric machine to add or remove torque.”

In charge depletion mode, the engine only runs when torque from the electric motor is insufficient, and when the engine does kick in it is to provide torque assistance only, since the battery state of charge is high; the priority then is to reduce instantaneous fuel consumption. In charge sustaining mode, however, the aim is to maintain the battery state of charge between 25 and 35 percent, through alternating drive from motor and engine plus engine-on parallel charging.

Key parameters
The battery state of charge is one of the key parameters determining whether the electric vehicle mode can be deployed, but, adds Chambers, “in charge sustaining mode, if you build up the state of charge towards the top of the 10 percent window, then we do allow EV mode again, especially at low vehicle speeds where it’s beneficial – and quiet.” Conversely, at higher speeds when fuel consumption is higher too, torque from the electric motor can be added to reduce the engine load – with the added advantage in the case of the 1.4 T engine of mitigating against turbo lag as well as supplementing performance.

As requested in the project brief, the Ricardo engineers also explored an alternative strategy with a range-extending mode in which the battery could be fully recharged to up to 80 percent capacity by the engine acting as a generator. This is unusual for a plug-in hybrid architecture as in ideal operation it would be less efficient than charging from cheaper mains electricity. However, this mode could give benefits and advantages in certain applications or scenarios and was hence included in the project.

Regenerative braking to recharge the battery was a further consideration. Though the potential for energy recovery via the brake pedal was restricted in these prototype vehicles in which the standard mechanical friction brakes were retained, the operating strategy allows for energy capture under deceleration. “When the driver lifts his or her foot off the accelerator pedal, you can recover some energy through the electric machine acting as a generator rather than a motor,” Chambers explains. “You can calibrate that to be very strong, if you want. We did also add a little bit more electrical regeneration from the brake pedal, but we were limited in these cars.”

Test cycle challenges
Overall, “it’s a balancing act between the efficiency of the engine and the efficiency of the electrical system,” says Chambers. And in order to both meet the Euro V benchmarks for emissions such as nitrous oxides and to achieve the target figures for fuel consumption and CO2 emissions under the NEDC test cycle (which includes an additional cycle for PHEVs in which the car starts with an empty or very low battery) preconditioning of the engine was a crucial factor. “You have to have some logic in the system which predicts when the engine is going to be needed,” he notes. “There are a couple of conditions you can look at to predict when the engine may be required for extra power: one is the vehicle speed getting close to the theoretical maximum in EV mode, and the other is if the battery level gets to within a certain margin of its minimum for electric operation. You predict you’re going to need the engine, start it, and heat the catalyst.” Though heating the catalyst demands the running of the engine at idle [with the clutch disengaged], this is enabled by the provision of torque from the electric motor to maintain drive. The application of knowledge such as this was key to the achievement by the engineering team both of the aggressive CO2 reduction targets and also control of regulated emissions in order to achieve the targeted Euro V compliance.

Although the basic control strategy algorithm across the four engine variants was essentially the same at this prototype stage, with only low-level calibration needed to accommodate their different characteristics, “one area where we did have to manage the variants carefully was on the emissions control to meet Euro V,” Chambers explains. “The main challenge was making sure the catalyst was hot as much as possible, and different engines heat the catalyst at different rates, so we had to calibrate differently.”

Getting all these balances right necessitated members of the team frequently visiting AvtoVAZ at its base near the Volga, sometimes for weeks on end. “There was a lot of travel to Russia on this project,” says Marshall. “We’ve not had one of the vehicles in the UK at all; they’ve all been built and commissioned in Russia, so any testing we’ve had to do was in Togliatti.”

This input resulted in the target figure for the programme – a reduction of carbon dioxide emissions to 115 g/km – being met by a comfortable margin and the prototype vehicles satisfying the Russian authorities in two demonstration events. From a 155 g/km starting point, the overall output of the 1.6-litre gasoline engine was reduced to just under 97 g/km, that of the 1.6 CNG unit just under 90 g/km. The output of the AvtoVAZ-built naturally-aspirated 1.4 was cut to less than 84 g/km (see table for further details). And despite being only in very early prototype stages of development in this PHEV application in the demonstrator vehicle, the all-new 1.4 T emitted 90 g/km, indicating its potential.
Few companies globally can match Ricardo’s impressive track record of achievement in the development of innovations for improved energy efficiency, cleaner fuels, and reduced noxious emissions and noise; few companies can boast such a track record in engineering leadership and the creation of new and disruptive technologies.

Now, as the company embarks upon a series of events and celebrations to mark the completion of its first century and addressing the new challenges that lie ahead, we look back to Ricardo’s origins in the England of the First World War and to the quietly powerful personality of its inventive and increasingly influential founder.

**Harry Ricardo – a polymath of the internal combustion engine**

The company that we today know as Ricardo plc was the original creation of Harry (later Sir Harry) Ricardo, a true pioneer of the internal combustion engine and exponent of clean, low emissions combustion and energy efficiency, and of the development of new and more refined fuels. Born in London in 1885, Harry Ricardo had from an early age exhibited
Ricardo Centenary

an interest in engines. While still at school he built an internal combustion engine of his own design, to act as a water pump at his family’s country residence. Today this engine is proudly displayed at the Ricardo Shoreham Technical Centre and was the subject in 2010 of an Engineering Heritage Award bestowed by the Institution of Mechanical Engineers. Harry Ricardo also demonstrated an entrepreneurial flair during his school days, developing an improved model steam engine which was marketed commercially under licence to the Liverpool Casting Company.

Harry’s interest in the internal combustion engine was further crystallized while studying from 1903 to 1906 at Cambridge University – the institution of that era later being rightly described as the birthplace of British automotive and aeronautical engineering and research. During this time it was one of the extra-curricular activities that was perhaps most formative in shaping his future. A competition was hosted in 1904 by the University Automobile Club to achieve the maximum mileage on one quart (1.1 litres) of fuel. Using a motorcycle of his own design with an engine design modified extensively and proven through experimentation, his machine – which was much heavier than most of its competitors – continued until just short of 40 miles: most of his rivals ran out of fuel after only 16 or 17 miles. Harry Ricardo would later describe this as “my greatest triumph, for I put my whole heart and all my thoughts into this achievement.”

After completing a period of post-graduate study at Cambridge, Harry took a position at his grandfather’s consultancy as a mechanical and civil engineer. Independently, however, his passion for internal combustion engine research and development continued in his own workshop at home. He developed an ambitious two-stroke engine, the Dolphin, and a car to house it. The project was a commercial venture by his cousin, Ralph Ricardo: though commercially unsuccessful and with just a handful built, the Dolphin experience provided a valuable lesson for Ricardo. More than anything else, it helped crystallize his idea for an organisation which carried out independent research and development rather than buying in parts and assembling vehicles for commercial sale.

Shortly after his wedding in 1911, a tour of German engineering companies strengthened his resolve to pursue the R&D approach, with the resulting inventions patented to derive a steady stream of income by licensing their use to vehicle manufacturers and suppliers.
Formation of the Ricardo company

Harry Ricardo’s first major success came at the height of hostilities in the First World War: the design of an engine which transformed the performance of the world’s first battle tank. This success provided the catalyst for the formation of the Ricardo company.

Ricardo’s tank engine design incorporated a range of new technologies to reduce smoke and improve performance and efficiency in the arduous environment of the western front. The new engine incorporated cross-head pistons, masked inlet valves and, crucially in an era before the existence of oil control rings, effective isolation of the combustion chamber from the oil. The engine exhibited no visible smoke – an important consideration in battle, where an exhaust plume could betray a tank’s position to enemy artillery – and was around 50 percent more powerful but constructed to the same package space and weight as its predecessor.

Used in a range of applications from railway shunting locomotives to generator sets as well as in tanks, the Ricardo engine was the most powerful and reliable automotive power unit available to the allies and became the UK’s first mass manufactured engine. The proceeds of this early success endowed Harry Ricardo with the resources to create the technical centre in Shoreham, which remains the UK and world headquarters of the company that he founded.

An enduring ethos

Unlike many firms of that period, the Ricardo company was – as its original name of Engine Patents Ltd implies – focused from the outset on the creation of new technologies and innovations, as opposed to engaging directly in the mass manufacture of engines or vehicles. Performance and sustainability have been the key watchwords over the hundred years since then. The technologies that the company has developed and the engineering assistance it has provided have led to the creation of improved fuels and more fuel efficient, better performing and higher quality products by its vast range of customers – products that range from two-wheelers and passenger cars to the largest and most powerful of railway locomotive engines, aero engines, marine propulsion systems, and off-highway and construction equipment.

While the company has expanded considerably from its early roots and operates today across multiple continents and industries, it remains...
true to this core ethos of excellence in engineering and clean technological innovation.

Celebrating the first hundred years
The Ricardo centenary year is being marked with a series of employee events at each of the company’s many international sites across the UK, Europe, the United States and Asia. The first public aspect of the celebrations has already been marked with the launch of the Ricardo 100 website – www.ricardo100.com – which provides a summary of the company’s history and which will be used throughout 2015 to provide news and information regarding events marking the Ricardo centenary year.

This will be followed later in the spring by the publication of a high quality book documenting the history of Ricardo, which will be made available to the public through the Ricardo online store. The book celebrates a century of landmark innovations across a wide variety of industries: it profiles the engineers — most notably Sir Harry Ricardo himself — whose ingenuity and foresight enabled the company to develop into the respected worldwide consultancy that it now is. The final section of the book turns the focus to the future, with leading figures in Ricardo, in industry, in academia and in government giving their individual visions of how the world will be 100 years from now — when Ricardo celebrates its second centenary in 2115.

Reflecting the company’s commitment to education and training, a Centenary Bursary is to be launched. This will provide assistance to students, initially from the Shoreham area, to support their university studies, and is an initiative that the company aims to roll out in the areas close to all of its other major UK facilities.

One of the most exciting employee initiatives of the centenary celebrations will be the ‘Ricardo 100 Global Challenge’, a round-the-world relay using some of Ricardo’s historic vehicle fleet as well as examples of the latest technology demonstrators developed by the company; also taking part will be production vehicles from Ricardo’s client companies that our engineers have helped to bring to market. The relay is planned to start from the Shoreham Technical Centre during the spring, heading east through Europe, Asia and the United States, before returning to Shoreham in time for the formal opening of the new low carbon Vehicle Emissions Research Centre.

True sustainability, asserts Ricardo chief operating officer Mark Garrett, “is not just measured in terms of our ability to reduce the carbon we release into the atmosphere, the resources we consume or the pollution associated with the emissions of transport and industry. For a business to be truly sustainable it needs to do all these things, but it also needs to be commercially profitable in order to sustain its own performance and develop world class talent for the future.

“Ricardo is one of very few companies that can demonstrate a commitment to pushing the boundaries of energy efficiency and clean technology for one hundred years,” explains Garrett. “This is clearly a cause for celebration for our employees past and present, for our customers and for our many other stakeholders around the world, as we look forward to many future successful years for Ricardo.”

Sir Harry’s innovative E35 variable compression ratio research engine (far left) enabled the systematic study of the combustion process and the characteristics of fuels. The internal combustion engine (left) designed and built by the young Harry Ricardo when he was still a schoolboy: it was used to pump water at the family’s country home.
Ricardo develops next-generation electric vehicle motor

A new prototype electric vehicle that avoids the use of expensive rare earth elements has been built by Ricardo.

The new motor – which provides uncompromised performance at significantly reduced cost – is the fruit of a collaborative research and development project, RapidSR (Rapid Design and Development of a Switched Reluctance Traction Motor). Ricardo’s partners in this research include project leader Cobham Technical Services and Jaguar Land Rover. The project, launched in 2012, is co-funded by the UK’s innovation agency, Innovate UK.

A highly innovative design, the 85kW synchronous reluctance electric machine uses low-cost materials, simple manufacturing processes and uncomplicated construction. Its rotor is made from cut steel laminations, which are used to direct and focus the flux across the air gap, thus maximising the flux linkage between the stator and rotor and enabling performance to be optimized within a tightly packaged, low-weight design that is entirely free of rare earth elements.

The prototype is now undergoing rigorous testing to validate the extremely positive results that it has shown in simulation. “As the market for electric vehicles grows globally, there is an imperative to explore alternatives to permanent magnet traction motors which require the use of expensive and increasingly difficult to source rare earth elements,” explained Paul Rivera, MD of the Ricardo hybrid and electric vehicle systems business. “This Ricardo prototype demonstrates what can be achieved by using the latest electric machine design processes in the creation of a high performing, compact, lightweight, and rare earth element free concept.”

TorqStor takes to the rails

Having already scooped a prestigious rail industry sustainability award, the latest generation of Ricardo’s award-winning TorqStor high speed flywheel is now undergoing testing on diesel multiple unit trains.

The application of advanced high-speed flywheel technology to save fuel in rail applications moved a step closer with the delivery in December of a Ricardo TorqStor evaluation prototype unit to Artemis Intelligent Power, which is collaborating with world-leading rail technology expert Bombardier Transportation and Ricardo on the Innovate UK-funded DDFlyTrain project.

Just a few days before, the project had received the award for the ‘Most Interesting Initiative in Safety and Sustainability’ at the Rail Exec gala dinner. For TorqStor, this accolade comes on top of the SAE World Congress Tech Award last April. TorqStor’s permanent vacuum – a unique feature among flywheel designs – saves both cost and weight, and is enabled by an advanced magnetic gear system.

Ricardo VP of Innovation David Rollafson, who accepted the award, commented: “The application of high-speed flywheel technology as an enabler for regenerative braking on the diesel multiple unit fleet has the potential to make an important contribution to reducing the carbon footprint of rail travel. This latest generation of Ricardo’s TorqStor high-speed flywheel energy storage technology is a breakthrough in terms of cost reduction and lightweighting as well as in energy storage efficiency.”

“This game-changing technology offers transformative potential to reduce costs and save fuel across a range of applications from commercial on-highway trucks to mining and construction equipment, and we are actively seeking further opportunities to realize the benefits of TorqStor in new sectors,” added Rollafson.
Ricardo forms US defence subsidiary

A new organization, Ricardo Defense Systems (RDS), has been formed by Ricardo to enhance opportunities for collaboration with US manufacturers and government agencies on defence-related vehicle technology development and engineering projects.

The formation of RDS builds on Ricardo’s strong track record of successfully addressing a wide range of critical challenges for its defence customers. The new subsidiary will have a dedicated facility at Ricardo’s existing Detroit Technology Campus in Van Buren Township, Michigan.

New technical collaboration with Cooper

Cooper Corporation – one of India’s leading engine manufacturers – and Ricardo are to jointly develop a new line of cutting-edge products ranging in power from 3.5 to 1000 KVA, with the entire range available in both diesel and CNG versions. Ricardo’s long-standing collaboration with Cooper has produced no fewer than 52 engine variants over a six-year period. This new range of engines will power applications for diverse sectors including automotive, gensets, marine, defence, construction equipment and agriculture.

Ricardo provides NVH support to China’s Qoros Automotive

Launched to great acclaim in the Chinese market in December, the brand new Qoros 3 City SUV has benefited from the collaboration on NVH integration support between Qoros Automotive – one of China’s newest and most ambitious automakers – and Ricardo. Ricardo engineering responsibilities embraced many aspects of NVH, ranging from issue investigation and resolution through to final NVH validation of the new vehicle.

Ricardo and Cascade Consulting have announced a formal collaboration in the areas of water resource management, water quality, ecosystem services and environmental impact assessment.

Cascade specialises in environmental consultancy services for the UK water sector, based on extremely strong relationships with the country’s water companies, as well as with government departments and regulators. The Manchester-based consultancy’s services are in ever greater demand as government and the industry seek to address challenges of climate change, increasing water demand, reduced water supply, rising standards for water quality, and the changing distribution of populations.

The memorandum of understanding has been signed between Cascade and Ricardo’s wholly owned subsidiary Ricardo-AEA. The collaboration will enable Ricardo-AEA to offer its clients ready access to world-class water consultancy, and represents a major expansion of its present water, economic, and climate change capabilities. The agreement will enable the company to provide consulting services on the increasingly important links between energy and water.

Cascade, in turn, will be able to offer its clients ready support in the form of Ricardo-AEA’s deep capabilities in climate change, energy, economic assessment, resource efficiency and air quality. Cascade will also be able to offer its core water capabilities through Ricardo-AEA’s extensive international client relationships.

“The collaboration with Cascade provides complementary capabilities that will develop and enhance our water offer, bringing it up to the strength of our other major technical teams advising clients on the key sustainability issues of the day,” commented Ricardo-AEA’s Director for Development Tim Curtis. “It will enable us to exploit the significant links between these topics, and also provides a major opportunity to take leading UK water expertise to our international clients.”

Ricardo and Cascade announce key water sector collaboration

Ricardo VP of innovation David Rollafson (centre) and Henry Dobson, research and development engineer for Artemis Intelligent Power (right) receive award from Allan Spence, director of safety strategy at Network Rail
A new partnership between Ricardo and aerospace composite supplier Albany Engineering Composites (AEC) will pull forward the introduction of advanced materials such as 3D composites into automotive manufacturing.

As part of the drive to reduce carbon emissions, automakers are incorporating a variety of new and advanced materials in order to reduce the weight of vehicle structures and components. The collaborative partnership between Ricardo and AEC, announced in February, will meet this demand by providing composite body, chassis and other structural components to the automotive industry, worldwide.

The key challenge is to find lightweight materials that have the requisite strength to ensure passenger safety. AEC has proven expertise in the aerospace industry for state-of-the-art design and manufacture of lightweight composite parts that are noted for their impact and damage tolerance.

“We're excited to leverage our experience with 3D and other advanced composite technologies in the automotive industry,” said Brian Coffenberry, vice president of business development for research and technology at AEC. “The ability to combine light weight with durability has been a technology enabler for our aerospace customers, and we believe our partnership with Ricardo can deliver the same technology advances to automotive customers.”

Ricardo and AEC will jointly explore the capabilities of AEC technologies like 3D composites to provide the stiffness, strength, durability and energy absorption necessary to lightweight applications such as crash structures. Generally these employ metals and are difficult to construct with lighter weight materials without compromising performance requirements.

“Industry experts forecast significant reductions in the cost of carbon composites, and with continuous improvements in related manufacturing cycle times, this becomes an attractive solution for the structural components of future global car platforms,” observed Ricardo plc chief operating officer Mark Garrett.

“The combination of Ricardo’s automotive engineering expertise and AEC’s technology, design and manufacturing capabilities should provide a unique opportunity to speed the implementation of advanced lightweighting solutions for our customers,” added Garrett.

Aerospace technology lightens automotive load

A new partnership between Ricardo and aerospace composite supplier Albany Engineering Composites (AEC) will pull forward the introduction of advanced materials such as 3D composites into automotive manufacturing.

As part of the drive to reduce carbon emissions, automakers are incorporating a variety of new and advanced materials in order to reduce the weight of vehicle structures and components. The collaborative partnership between Ricardo and AEC, announced in February, will meet this demand by providing composite body, chassis and other structural components to the automotive industry, worldwide.

The key challenge is to find lightweight materials that have the requisite strength to ensure passenger safety. AEC has proven expertise in the aerospace industry for state-of-the-art design and manufacture of lightweight composite parts that are noted for their impact and damage tolerance.

“We're excited to leverage our experience with 3D and other advanced composite technologies in the automotive industry,” said Brian Coffenberry, vice president of business development for research and technology at AEC. “The ability to combine light weight with durability has been a technology enabler for our aerospace customers, and we believe our partnership with Ricardo can deliver the same technology advances to automotive customers.”

Ricardo and AEC will jointly explore the capabilities of AEC technologies like 3D composites to provide the stiffness, strength, durability and energy absorption necessary to lightweight applications such as crash structures. Generally these employ metals and are difficult to construct with lighter weight materials without compromising performance requirements.

“Industry experts forecast significant reductions in the cost of carbon composites, and with continuous improvements in related manufacturing cycle times, this becomes an attractive solution for the structural components of future global car platforms,” observed Ricardo plc chief operating officer Mark Garrett.

“The combination of Ricardo’s automotive engineering expertise and AEC’s technology, design and manufacturing capabilities should provide a unique opportunity to speed the implementation of advanced lightweighting solutions for our customers,” added Garrett.
Examples of Bespoke Courses include:

- Diesel particulates and NOx control
- Crank case lubricants
- Chassis and vehicle dynamics
- Life cycle analysis (LCA)
- Manufacturing
- Introduction to on board diagnostics (OBD)
- ISO 26262

Testimonials:

- "This course has provided a valuable detailed insight into engine construction and market drivers. But more than that it was a thoroughly interesting course at a world class organization."

- "Excellent knowledge transfer from the enthusiastic presenters at the cutting edge of their field."

For more details, please contact:
Sean Howell on +44 (0) 1273 794021
or Alan Laccohee on +44 (0) 1273 794984
or email traininginfo@ricardo.com
SOLVE YOUR URGENT ENGINEERING ISSUES

CRITICAL ISSUE RESOLUTION

A fast, global and comprehensive response to your critical technical issues

- Warranty problems
- Quality concerns
- Programme gateways at risk

Contact Ricardo today for an instant response

www.ricardo.com/CIR

Email: IssueResolution@ricardo.com
Tel: (Europe) +44 (0) 1273 794700  (US) +1 734 394 4200

Delivering Excellence Through Innovation & Technology