REGULATORY LANDSCAPE:
Regulation is one of the major drivers of change within the automotive sector; changes happening at almost every level are forcing an evolution of the sector.

THE INNOVATION GAME:
David Moss, Nissan’s Vice President, Vehicle Design and Development, discusses LCV innovation.

LOW CARBON VEHICLES: THE ROAD TO A CLEANER FUTURE
While the internal combustion engine will remain part of the automotive ecosystem for some time to come, there is an increasing need to conserve fuel and minimise emissions while maintaining compelling consumer propositions. This is leading to increased electrification of the vehicle powertrain, which in turn is disrupting incumbent supply chains, and providing opportunities for organisations willing to embrace change.

Organisations operating in the UK can build upon the advantages and capabilities afforded by the British automotive sector, allowing them to capitalise on these technology-led disruptions to existing supply-chain positions. It is clear, however, that international competition for these opportunities is fierce and that the incumbent supply chain is very strong. The UK must therefore act quickly and use collaboration to mount an effective challenge, if these opportunities are not to turn into threats.

Global climate-change and air-quality agendas are driving rapid technological change within the automotive sector. This, in turn, is creating new opportunities globally, as international, national and local regulations drive action on CO₂ emissions and other air pollutants. At the same time, technological evolution is disrupting many sectors. Automotive, for example, is seeing a huge push for the long-term development of connected and autonomous vehicles.

Fortunately, the UK is well placed to capitalise on these trends. The UK market for low-carbon and low-emissions technologies is accelerating faster than many others in Europe. The UK automotive sector operates in a unique environment, with strategic alignment between industry and government support. The UK combines world-leading research, world-renowned aptitude for innovation and world-class manufacturing productivity.

Combining these advantages in a collaborative approach underpins the aims of the Advanced Propulsion Centre (APC) programme. The APC co-invests in collaborative research and development projects, building upon UK government investments made via the Engineering and Physical Sciences Research Council and Innovate UK, to accelerate the development of low-carbon and low-emissions technologies towards production. In addition, the APC is facilitating broader collaboration through the Spokes network, which draws together communities with a common technical interest.

At the APC we have identified a number of opportunity areas that align strong capability and good potential for growth in organisations operating in the UK with likely market demand. These provide the potential for the UK to assert a strong future supply-chain position, given suitable investment. Identifying these opportunities is a step towards providing a foundation for further dialogue and focused support, to build on existing advantages in these areas.

Our programmes explore the opportunities arising from strategic technologies identified by the Automotive Council. Aside from the internal combustion engine, these programmes support development in electric machines and power electronics, energy storage and management, and lightweight vehicle and powertrain structures.
The Advanced Propulsion Centre (APC) was formed in 2013 from a commitment between the Government and the automotive industry through the Automotive Council to position the UK as a global centre of excellence for low-carbon powertrain development and production. APC is a central pillar of the industrial strategy created by the Automotive Council.

The APC is a private limited company, an industry-wide collaboration of innovators and producers of low-carbon propulsion systems. It facilitates partnerships between those who have good ideas and those who can bring them to market. The services provided by the APC enable projects that provide profitable growth and sustainable opportunities for the partners involved. Each programme enhances the UK’s position as a “propulsion nation” and contributes to the country’s economic prosperity.

The Government and industry have each committed to provide £500 million to the APC during its ten-year programme. The activity in this £1 billion project will be delivered through a small team working across the UK from a central hub located at the University of Warwick and in regional Spoke locations. Find out more about the APC at www.apcuk.co.uk.
The UK remains in pole position to take advantage of the growth in low-carbon vehicles (LCVs), a global industry that has been buoyed by a focus on cutting carbon from our roads and meeting tough targets to clean our air. In the UK, for instance, there are plans for an 80 per cent reduction in the CO2 produced by transport by 2050 – and that means huge opportunities for innovative businesses. “The UK has had a leading role in the development and introduction of low-carbon vehicles,” says Professor David Greenwood of WMG at the University of Warwick. “We have a very strong research community, excellent design-engineering, innovative businesses. The UK has had a leading role in the development and introduction of low-carbon vehicles,” says Professor David Greenwood of WMG at the University of Warwick. “We have a very strong research community, excellent design-engineering, and the UK supply chain needs to act quickly”.}

SUPPLY CHAIN BOOST
One area in which the UK does struggle is its lack of tier one suppliers, which in the automotive industry means those key businesses that integrate new technologies into packages that the vehicle manufacturers can incorporate into their products. This is one of the issues addressed by a recent capability report into Low Carbon Automotive Propulsion Technologies from the Advanced Propulsion Centre – a decade-long, £1 billion partnership between the Government and the automotive industry. The report talks of a technology-led disruption of existing supply chains, which, coupled with the UK’s resurgent vehicle-manufacturing sector, is creating a window of opportunity for UK supply businesses. But, warns the report, “the competition is fierce and the UK supply chain needs to act quickly”. A key objective of the Advanced Propulsion Centre has been to help develop these supply-chain capabilities by attracting international tier one companies to set up in the UK, building links with suppliers in adjacent industries and helping small and medium-sized enterprises (SMEs) grow their capabilities. It is the symbiotic relationship between every element of the supply chain that means each new breakthrough is of benefit to the UK automotive sector as a whole.

SCIENTIFIC EXPERTISE
The UK has proved adept at “exploiting its science base”, according to Neville Jackson, Chief Technology and Innovation Officer at the R&D organisation Ricardo. “The next generation of battery chemicals, lightweight materials and more efficient combustion engines are all areas in which the UK excels”, he says, “with the technology often developed on the back of our existing expertise in Aerospace and Formula One. Improving the combustion engine involves engineers taking a holistic approach, optimising how all the parts of the engine work together and then reclaiming the waste heat – something that’s often referred to as a thermal propulsion system”, explains Jackson. The engine in a normal passenger vehicle operates at a maximum of around 33 per cent, while Formula One engines achieve closer to 50 per cent. “So there is considerable scope to improve,” he says, believing that around 60 per cent is, perhaps, achievable in the medium term.

While the UK is home to many global automotive players, many of the other companies that have pushed the UK to the forefront of LCV technology are SMEs and University spin-outs. These include Edinburgh-based Celtic Renewables, which is commercialising Biobutanol – made from the residues of the Scottish malt whisky industry – as a new biofuel. Elsewhere, Controlled Power Technologies is developing a new generation of technologies for more affordable “mild” hybrid vehicles, while Tevva is working on the first range-extended urban delivery truck.

Another key factor in the UK, continues Jackson, is “the strong working relationship between industry and government and how it supports and accelerates research and development so it can have real impact”. The Advanced Propulsion Centre has created a Spokes Network charged with bringing academic and industrial research and development communities together to collaborate in all aspects of research, from fundamental science through to product industrialisation.

The Advanced Propulsion Centre Spoke communities act in a coordinated way as ‘centres of excellence’ throughout the UK, with the Network providing a consolidated national resource of facilities and expertise. The spokes are designed to provide access to the best expertise and facilities the UK has to offer for each of the key strategic technologies for the automotive industry.

And it is this focus on improvements that has led to a renaissance in global exports. Both Indian car manufacturer Tata and
Chinese automotive giant Changan have set up technology innovation centres in the West Midlands, ensuring the UK’s DNA is now found in automotive products all over the world.

**LOW-CARBON FUTURE**

According to Jackson: “There is a whole range of things we need to look at, from electrification through to more efficient combustion engines and low-carbon sustainable fuels.

“It’s all about different applications. If you want to drive around the city, with low speeds, low power and relatively low-energy requirements, a battery-based vehicle makes a lot of sense,” he says.

However, if you want to drive between cities, he says, a hybrid gives you the range and the option to switch from petrol to electric. “And for heavy-duty transport, you need to start looking at more efficient combustion engines and more sustainable, low-carbon fuel.”

Meanwhile, Greenwood observes: “I hope we don’t see a short-term rejection of diesel technology as a result of the VW scandal – particularly as new diesel vehicles arguably represent a cost/benefit solution to vehicle cost and emissions reduction.

“We will see electric motors and power electronics get better and we’ll see a continuing improvement in battery technologies – all of which will lead to cheaper and longer range electric and hybrid vehicles.”

Developments that are all good news for the consumer, as well as the UK’s automotive sector.
According to the European Environment Agency (EEA), the average emissions level of a new car sold in 2015 was 119.6g of CO\(_2\) per kilometre, significantly below the 2015 target of 130g.

**Did you know?**

PC200-8
In 2008 Komatsu Ltd. launched the PC200-8 excavator, the world’s first hybrid vehicle used in construction.

HONDA CLARITY
In 2008, Honda introduced the FCX Clarity which was available for lease in the US, Japan and Europe.

**Did you know?**

In 2001, the UK government changed vehicle excise duty and taxed the amount of CO\(_2\) emitted rather than the engine size.

**Did you know?**

By 2020 the SMMT predict that the UK will be making more than two million cars per year, higher than the all-time record of 1.92 million in 1972.

**Did you know?**

Some manufacturers claim that the UK currently produces only half the number of engineers it needs to meet demand.

**Did you know?**

At the 2015 Paris COP21 conference, the UK government reaffirmed its commitment for almost all cars and vans to be zero emission by 2040.

**Did you know?**

In April 2014, The APC awarded £2.8 million to four projects.

**Did you know?**

In November 2014, The APC awarded £16 million to two projects.

**Did you know?**

In 2005 to 2009, Wrightbus single-deck electricers were ordered in March 2005 to operate on route 360.

**Did you know?**

In 2013 The BMW i3 was launched with the additional option of a petrol range extender and featured lightweight composite materials to increase fuel efficiency.

**Did you know?**

In 2015 the Nissan LEAF was launched proving electric vehicles could become viable in the mass market. As of 2014, Nissan had sold 98,000 LEAFs around the world.

**Did you know?**

In 2009 three-cylinder Ford EcoBoost engine was produced achieving approximately 20% better fuel efficiency and 15% reduced greenhouse emissions.

**Internal Combustion Engines emerge as the dominant technology**

**Key LCV Innovations over time**

**Stop/Start**
Given the success of stop/start engines in hybrid vehicles, car manufacturers incorporated the technology into internal combustion engines.

**Hydrogen Buses**
Between 2004 and 2007, three trial fuel cell powered Mercedes-Benz Citaros were used on the RV1 route in London.

**Kinetic Energy Recovery System**
The first Kinetic Energy Recovery System was used in the 2009 Formula One season.

**Internet of Things**
Improved energy systems

Developments in fuel cell technology

Self driving vehicles

Improved power electronics and electrical machine systems

**Toyota Mirai**
Toyota’s fuel cell powered Mirai went on sale in Japan in 2014 and is scheduled for sale in Europe and America mid-2015.

**Nissan Leaf**
Nissan Leaf in 2010, the Nissan Leaf was launched proving electric vehicles could become viable in the mass market.

**Ford EcoBoost**
In 2009 the first three-cylinder Ford EcoBoost engine was produced achieving approximately 20% better fuel efficiency and 15% reduced greenhouse emissions.

**Tesla**
In 2003 Tesla Motors was founded by Elon Musk. In 2008 they released their first car which used lithium ion batteries.

**BMW i3**
In 2013 The BMW i3 was launched with the additional option of a petrol range extender and featured lightweight composite materials to increase fuel efficiency.

**Honda Clarity**
In 2008, Honda introduced the FCX Clarity which was available for lease in the US, Japan and Europe.

**Wrightbus**
The first hybrid electric bus entered service in London. Six Wrightbus single-deckers were ordered in March 2005 to operate on route 360.

**Toyota Mirai**
Toyota’s fuel cell powered Mirai went on sale in Japan in 2014 and is scheduled for sale in Europe and America mid-2015.

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lobally, the international community is moving towards ratification of the UNFCCC’s 2015 Paris Agreement, the world’s first comprehensive climate change agreement. This would see countries enact legislation to peak emissions, and keep emissions below the point of causing 2°C warming.

In September 2016, both the US and China ratified the agreement prior to the G20 summit, taking ratification from 1 per cent of global emissions to 37 per cent. And, while individual countries may take their own approaches to cutting emissions, transport is a major sector to be affected.

Aside from the impact of the Paris Agreement, the EU has already committed to cutting emissions by 40 per cent by 2030 (based on 1990 levels). EU leaders have also endorsed an 80 to 95 per cent reduction in emissions by 2050. A low-carbon roadmap has been produced to show how this target could be achieved, which includes binding targets on the level of emissions allowed from new cars and vans. The EU also has limits on the emissions of NOx and SOx, as well as particulates. There are, however, likely to be increasingly robust regulations of all emissions.

Following 2015’s controversies around the difference between lab-based CO2 emissions and emissions from real-world driving conditions, the European Commission is now looking to bring test centres under greater scrutiny. Draft regulations suggest the introduction of spot-checks for manufacturers, as well as peer review between different national approval centres. They also request access to each car’s software protocols—an effort to limit the future use of defeat-device software.

In the UK, the 2008 Climate Change Act committed the country to an 80 per cent cut in emissions by 2050 (from a 1990 base). As part of this non-traded sector (NTS), transport was not covered by EU CO2 trading rules, so it is expected to play a larger role in the UK low-carbon roadmap. While a large CO2 saving will come from increased fuel efficiency, renewable energy (generating electricity) is expected to play an increasingly large role over time. Electrification of transport through battery-electric, hybrid or fuel-cell vehicles will provide fundamental opportunity for reducing the carbon emissions from light vehicles in particular.

There is no doubt that the overwhelming trends in automotive are for increased efficiency, higher voltage electronics, lightweighting and electrification. Add to that the interest in the potential of the internet and the growing connectedness of our environment, and the change looks unstoppable. “We’re in the middle of a transport revolution, with new energy vectors and a change in the way that we use vehicles—from ownership to mobility as a service, and to newly autonomous and connected vehicles,” says Denis Naberezhynkh, head of Ultra Low Emission Vehicles and ITS technology at the UK’s Transport Research Laboratory (TRL).

Industry and academia have come together to promote collaborative research and product development. Iwan Parry, a principal consultant at TRL says: “Because of a high level of OEM, research and engineering skills, we can take risks and trial new technology, which could enable us to leapfrog the competition and develop in-country know-how.”

According to Parry, who works on the TRL’s GATEway (Greenwich Automated Transport Environment) project, which is testing driverless vehicles, “The UK is held up as a good example of how governments can support an open testing environment.”

What makes the UK market unique is the way in which government, industry and academia have come together to promote collaborative research and product development.
plays a vital role in the industry’s success, saying, “It’s a way of encouraging collaboration for the development of market-facing capabilities in this sector.” It’s also crucial that such projects highlight issues around common standards for communication and security. An understanding of these issues will be vital both for the development of an effective legal framework and for the reassurance of the consumer.

As Sajid Javid, Secretary of State for Communities and Local Government, said of the Greenwich project: “Making driverless cars a reality is going to revolutionise our roads and travel – making journeys safer, quicker, more efficient and environmentally-friendly. Very few countries can match our engineering excellence in the automotive sector or our record of innovative research, and this announcement shows we are already becoming one of the world’s leading centres for driverless car technology.”

Getting regulation right and encouraging industry development in a way that will enable the UK to lead this automotive transition could have a significant economic impact. The new Bill is intended to provide a framework to underpin a shift in transport models, ensuring safety standards, proposing new approaches to insurance and liability and encouraging further investment.

Cars with advanced driver-assistance features, such as remote-control parking and motorway assist, are expected to be on sale in Britain in the next two to four years, with automated and driverless vehicles expected on the roads any time from the mid-2020s onwards. The government has also announced a new fund to enable councils to invest in new infrastructure technologies. Parliamentary Under Secretary of State for Transport Andrew Jones said: “Britain has a proud history of innovation and I am delighted councils will be able to use this money to develop systems to make journeys easier and safer.”

Proposals include using technology that will allow vehicles to communicate with each other and roadside sensors to provide drivers with real-time traffic information. Councils will also look at how warnings about changing weather and traffic conditions can be sent directly to vehicles, so drivers can plan ahead – helping deliver quicker, more efficient and safer journeys.

Government funding
Of course, success in these areas has demonstrably been dependent on the wide-ranging collaborations within consortia. One of the key concerns for many stakeholders has been the potential fallout from Brexit, and the impact on finance, skills and markets.

Billions in European funds have been available (not least the £80 billion in Horizon 2020 funds) and the cross-country collaborations between companies, academics and engineers have been crucial to the industry’s success.

A recent announcement assuaged a good deal of that concern, when the Treasury announced it would underwrite funding for approved Horizon 2020 projects applied for before the UK leaves the EU – a commitment to safeguard funding for research and innovation projects.

Secretary of State for Business, Energy and Industrial Strategy Greg Clark said: “The Government’s commitment to our world-leading science and research base remains steadfast. By underwriting the significant Horizon 2020 grants that it has already given significant initial support to, Britain is ensuring that the research which underpins the UK’s lead in the emerging field of autonomous vehicles will be delivered.”

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UK INVESTMENT IN LOW CARBON TECHNOLOGIES

Funding allocation by technology area £ millions

- £161 for Engines
- £34 for Transmission, Driveline and Kinetic Energy Recovery Systems
- £122 for Traction Electric Machines and Power Electronics
- £124 for Traction Batteries and Fuel Cells
- £101 for Lightweight Technologies

£542 million granted to 427 low carbon related projects during 2010 to 2015

<table>
<thead>
<tr>
<th>Technology Maturity</th>
<th>Principal Agency</th>
<th>Number of Projects</th>
<th>Total Grant Value £(m)</th>
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<td>Applied</td>
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Patent filing activity suggests that UK organisations are not fully capitalising on low carbon propulsion technology opportunities. The Advanced Propulsion Centre’s Low Carbon Propulsion Technologies capability report identifies 21 opportunities for which the UK is well placed to capitalise upon.

Source: Low Carbon Automotive Propulsion Technologies report produced and published by the Advanced Propulsion Centre.
Having recovered from what appeared to be terminal decline at the end of the 1990s, the automotive sector was then hit harder than most by the economic crash of 2008. "In the case of the UK, it was a do-or-die moment," says Adam Chase, a director at the tech consultancy, E4Tech. "Concerted action was needed, or the industry risked disappearing altogether."

To survive, radical action was needed, and the Automotive Council was to prove a central player. Set up in 2009, and made up of senior figures from across the industry and government, it encouraged businesses and manufacturers to put aside their natural rivalries for the good of the sector as a whole. One of the Automotive Council’s first important jobs was to coordinate the remaining key industrial players to roadmap the future of the sector and identifying which technologies could be built upon to drive the industry forward. Five key technologies were chosen: internal combustion engines; energy storage; intelligent mobility; lightweight vehicles; and electric machines and power electronics, all areas that have proved crucial to the growth of LCVs.

Support network
"The UK Government has played an important role in both creating a market for low-carbon vehicles, and supporting manufacturers to develop and introduce them," says David Greenwood, professor of Advanced Propulsion Systems at the University of Warwick. "The UK is unique in having a well-networked automotive community, and a strong dialogue between industry and government, which has put in place a world-leading support mechanism for the development and deployment of new technologies."

This mechanism begins with early-stage research supported by the Engineering and Physical Sciences Research Council. This is followed by funding for translational research from Innovate UK, and culminates with financial backing around commercialisation and industrialisation from the Advanced Propulsion Centre (APC). And it’s these continued rounds of funding, suggests Chase, that, "gave innovators the confidence to start the journey, knowing that it wasn’t just a one-shot thing."

The results of the last round of APC funding were announced in January 2016 and included grants of £46.5 million to a zero-emitting vehicles project from the London Taxi Corporation, £6 million to the Morgan Motor Company to develop hybrid and all-electric sports cars, and £5.4 million to a battery-pack generation scheme from a consortium led by A&M Batteries. Without this type of funding, argues Jon Beasley, the APC’s director of technology and projects, research and demonstrator projects developed in the UK would be snapped up by foreign interests, and developed and manufactured elsewhere, resulting in lost opportunities for the UK.

Low-carbon vehicles (LCVs) have reinvigorated an ailing sector and with political will, industry collaboration and touch environmental policies, the future is bright for UK automotive movement of researchers and skilled employees is very important for both academia and industry, and access to collaboration with European research institutes is at least as important as the money which comes with it. "We have already seen European consortia reluctant to take on UK organisations due to uncertainty over their future eligibility. We hope this is a temporary situation."

Another important consideration, says Beasley, is that the UK’s automotive success is in part based on strong exports. The Government, he argues, will need to help companies comply with any new international legislation and trade agreements.

Chase agrees: "It’s important that the Government provides as much certainty as possible and facilitates access to inter-global markets for UK innovators."

Another potential worry is that European clear-air targets, which have played such an important role in driving forward LCVs in the UK, will have less impact post-Brexit. However, says Greenwood, “it is highly unlikely that the UK would adopt vehicle emissions regulations which are significantly different to the EU, not least as vehicles are designed for large markets in order to achieve economy of scale, and it would be largely uneconomic for manufacturers to produce UK-specific derivatives.

“In practice the UK has had a strong role in driving EU emissions regulation, so if allowed to set its own, they would likely end up very similar.”

The UK’s automotive industry is in rude health once again but, warns Beasley, there’s no room for complacency. “Others are already looking at the UK and trying to copy what we do. If we sit back and let it happen, they will overtake and we will find it very hard to re-establish the advantages we have spent time and effort in building.

“The UK needs to continue to be seen as an attractive and competitive place to do research, business and to invest in, and to achieve this the sector will need continued government support.”

Consumer appeal
Globally, the growth in LCVs shows no sign of slowing. Last year, sales reached the one million mark for the first time, and a recent report from HSBC predicts that by 2020, 8.65 million electric vehicles and 5.23 million hybrid plug-ins will have been sold worldwide. Elsewhere, analysis by Bloomberg New Energy Finance has suggested that electric vehicles will be cheaper than conventional cars, on a total-cost-of-ownership basis, by 2022.

To take advantage of this, and to continue to meet climate-change targets, government intervention needs to keep stimulating interest in LCVs among consumers, making them more attractive to buy and helping the industry move from “early adopters” to a mass market with incentives such as taxation based on vehicles’ CO₂ emissions. It will likely also fall upon the Government to broker any deals around infrastructure issues, such as building a more advanced recharging network to support electric cars, and reinforcing the grid.

A post-Brexit world
But perhaps the biggest test of the Government’s continued commitment towards the industry will be the way it deals with any post-Brexit fallout. Access to the EU’s Horizon 2020 programme has been a particularly important source of research funds, says Greenwood, but he fears this may now change. And although the Government has said it will underwrite any funding shortfall as a result of Brexit, in practical terms Greenwood warns that, "free
T he UK automotive sector is the most productive in Europe, with productivity around 50 per cent higher than overall UK manufacturing. The sector comprises nearly 3,000 businesses including major vehicle manufacturers, engine manufacturers and supply-chain companies, as well as the world-class Formula One sector. Together the industry employs around 163,000 people, supports a further 330,000 jobs indirectly and contributes £14.5 billion to the UK economy.

According to the Confederation of British Industry, over 80 per cent of the vehicles manufactured in the UK today are exported, and more than 50 per cent of exports go to the EU. A survey undertaken by the Society of Motor Manufacturers and Traders earlier in 2016 reported a planned £325 million investment by SMMT supply-chain members over the next three years, as efforts continue to boost the British content of vehicles built in the UK.

RESEARCH AND DEVELOPMENT

Manufacturing output is part of the equation, but the UK is also home to research and development (R&D) centres for Jaguar Land Rover, Ford, Bentley, Rolls-Royce, Nissan and many more world-class players. At the same time, the supply chain has a critical role to play in the development of the wider UK automotive industry. It consists of over 3,000 companies contributing an annual £4.3 billion direct to the UK economy. The sector has undoubtedly suffered significant setbacks in past decades but is now undergoing a renaissance: 41 per cent of the components in the average British-built car are now sourced locally, up from 36 per cent in 2011.

R&D tax credits and the Patent Box are important in supporting in-house research, rewarding the development of new ideas and intellectual property by providing corporate tax relief.

INNOVATION THROUGH COLLABORATION

The critical enabler for the industry’s success, however, has been the working relationship between the Government and industry, working closely together through the Automotive Council. One of the key initiatives for the Automotive Council and the Department for Business, Energy and Industrial Strategy (BEIS) has been to improve the alignment of government support and funding throughout the innovation cycle. This approach is widely regarded as being one of the best aligned government funding mechanisms in the world, and as a working model for many countries.

This alignment of technology-led research to manufacture supply-chain support spans the Engineering and Physical Sciences Research Council (early stage/university research), through Innovate UK (demonstrator/businesses) and the Advanced Propulsion Centre (applied). Between 2015 and 2020, via the Office of Low Emission Vehicles alone, the Government has committed spending more than £600 million to support the uptake and manufacturing of ultra-low emission vehicles (ULEVs) in the UK. This will ensure that all cars and vans on UK roads will effectively have zero emissions by 2050.

OLEV and Innovate UK work very closely together to fund R&D activity, a relationship that goes back to 2007. In April 2016 OLEV and Innovate UK awarded £38 million for greener cars, from their IDPi2 and Lightweight Vehicles competition. Transport minister Andrew Jones said of the awards at the time: “This competition continues our £600 million commitment by 2020 to support the uptake of ULEV’s, making journeys cheaper and greener, ensuring the nation is fit for the future.” OLEV is also operating a “go ultra low cities fund”, to encourage schemes that incentivise low-carbon transport.

Innovate UK and the Office for Low Emission Vehicles (OLEV) at the same time announced a grant to a consortium including Jaguar Land Rover and Nissan to receive £1.7 million for “light-weighting” technology – applying the science behind F1 cars and space satellites to make passenger cars weigh less and be more fuel efficient. The results could reduce the weight of steel components in vehicles such as the Nissan LEAF by more than half, potentially extending the distance a plug-in car can drive by up to 25 per cent.

Finally, support from the Niche Vehicle Network who fund smaller, shorter term R&D projects from the UK’s buoyant niche vehicle manufacturers completes the picture.

One of the challenges for automotive funding is that it can be capital intensive, and the products, and their components, operate within a complex ecosystem. As well as the well-established Innovate UK IPD programme and smaller competitions run in collaboration with the Niche Vehicle Network the Advanced Propulsion Centre also operates a Technology Developer Accelerator Programme, specifically created to support small and medium-sized technology developers with low-carbon propulsion technology that can be applied to the automotive sector space. Global businesses should not ignore these world-class entities in the UK with their breadth of expertise and know-how. Without them, LCV innovation would brake to a standstill.

BUILDING ON SUCCESS

What is important in the UK is that we continue to build on our success and explore additional funding streams that will help ideas reach the market. There have been concerns over access to EU research funding following a vote for Brexit. Louise Mothersole at Innovate UK says, however, “there are hundreds of millions of euros available each year for the automotive sector’s advanced manufacturing, materials and digital businesses based in the UK, with over €100 million for research, development and innovation of on-vehicle technology for ultra-low emissions.”

OLEV supports a further 330,000 jobs in the world-class automotive sector space. Global competitiveness for Britain depends on talent in these specialist fields. With the UK market unique is the way in which government, industry and academia have come together to promote collaborative research and product development. Iwan Parry, a principal consultant at TRL, says: “Because of a high level of OEM, high-level research and engineering skills, we can take risks and trial new technology, which could enable us to leapfrog the competition and develop in-country know-how.”

The Advanced Propulsion Centre supported around £75 million1 worth of projects early in 2016 to the winners of its fourth-round competition: projects to develop new low-carbon and energy-efficient technology in the automotive sector:2
• £6.5 million for a The London Taxi Corporation project to deliver a series of lightweight, zero-emission-capable, range-extended vehicles
• £6 million to Morgan Motor Company to develop heavily downsized, fuel-efficient petrol engines coupled with the latest electrification technologies to produce hybrid sports cars and all-electric variants
• £5.4 million to a consortium led by AGM Batteries to develop the next generation of battery packs for high-performance LCVs
• £13.1 million to a project led by Jaguar Land Rover to build up the automotive turbocharger supply chain in the UK

1 ASI figures denote total project fund, not grant fund figures
2 These five projects are expected to create and protect 651 jobs and save over 4.2 million tonnes of CO2. They build on the 10 low carbon projects already awarded funding by the Advanced Propulsion Centre which are forecast to create 4,100 jobs and save 12 million tonnes of CO2.
BRIDGING THE SKILLS GAP

Ensuring that the UK has a new wave of skilled workers, adept at using the latest technologies, is crucial to ensuring the UK automotive industry remains competitive.

Advanced Propulsion Centre (APC). “The APC funding has brought together projects at Nissan Sunderland, which by their collaborative nature have research institutes involved carrying out industrial research. These include established universities such as Brunel, Newcastle and Warwick who are bringing their research to help deliver new technology. Zero Carbon Futures are working between the OEM (Nissan) and the universities to develop curriculum-based learning to upskill staff who will have to implement the technology, as well as into the learning of apprentices entering the workforce.”

However, the skills gap, Dr. Herron adds, also goes far beyond what is required for the research, development and manufacturing supply chain. “Vehicles coming on the market have got such a range of integrated technologies that if someone isn’t translating the required skills to the practical people who have to make, repair and service them, then we will have a problem.”

COLLABORATION IS KEY

In academia, and specifically in the low carbon engineering niche at UK universities, collaboration between learning entities and potential employers is seen as the key factor in helping reconcile the dearth of automotive skills in the UK with the fiercely competitive global landscape. “To be able to survive stringent global competition, the UK automotive industry needs to be continuously fully equipped with new knowledge, new technologies and most importantly new world-class engineers,” says Rui Chen, professor in low carbon power engineering at the Department of Aeronautical and Automotive Engineering at Loughborough University. “Current success will not be sustainable if the industry lacks the right skills.”

A compelling example of collaboration between academia and industry was brought about when Coventry University and Unipart teamed up to offer engineering students a new way to acquire the skills employers require. “Unipart, like a lot of manufacturers, was finding barriers to grow their business, and one of them was skills – a problem across the whole sector really,” explains Professor Carl Perrin, director of the Institute for Advanced Manufacturing and Engineering and executive director of the Manufacturing and Materials Engineering Research Centre.

This September the relationship goes into its third year intake and the first students will graduate in June next year. “A lot of people are interested in hiring them,” says Professor Perrin. “Some of them have already been offered jobs. What I’m trying to do now, having tested this different way of working, is look for ways we can expand the model and find new partners to grow it.”

Stakeholders in the banking and investment community are equally interested in the skills the UK manufacturing industry and to help tackle the sector’s shortfall in skills. The centre, which is part of the Government’s Catapult initiatives, provides an opportunity through engineering apprenticeships for those entering industry to acquire the skills needed for projects that, “are redefining manufacturing techniques of the future, including those in the automotive sector such as robotics and intelligent automation,” explains Atkinson. But to get to the point of attracting school-leavers into apprenticeships or engineering courses at universities, the seeds of interest in STEM subjects have to be sown at the earliest-possible juncture. That’s the strategy behind Shell’s raft of educational initiatives, which include “Tomorrow’s Engineers”, a national £1 million programme endorsed by the Department for Business, Energy and Industrial Strategy provides 11 to 14-year-olds with hands-on engineering experiences, careers information, and helps them appreciate the incredible range of opportunities that a technical career can provide.

In specific recognition of low-carbon imperatives, Shell recently launched a new school programme, “Energy Quest”, familiarising students with STEM subjects “in a fun and engaging way” using workshops and classroom-based modules that help students get acquainted with new energy sources and eco-friendly tech. Over the next three years the programme will reach more than 70,000 students in over 650 schools.

In a similar vein, independent charity Inspiring Foundation introduces 8 to 16-year-olds to the fascinating world of engineering and technology through fun, hands-on activities. Young engineers are Jaguar Land Rover and National Grid, bound to the Foundation with a vision to “enthuse and nurture young engineers of the future”. Activities include fairs and clubs for young people, much of them reliant on after-school clubs run by volunteers, many of them retired engineers.
There is no doubt that the UK is one of the most interesting markets for low carbon vehicles. Obviously the country has a degree of technology readiness but it’s the combination of this readiness with significant R&D strength, and the ability to scale development that makes the UK unique. Innovate UK is part of a specialist innovation ecosystem which has been held up the world over as an example of how to support the development of an industry. There are various elements of this: infrastructure and government funding; world class government; skills and talent; and multiple, deep sources of funding at each innovation stage; networks and exchanges across business, science and finance; strong advisory and mentoring networks.

As Edmonds says, “in the UK it’s a very applied research world in this sector.” Innovate UK sits in the middle tier where companies take research and turn it into viable products, where we co-fund development of projects. This is often with technology supported initially by the Engineering and Physical Sciences Research Council (EPSRC), which supports most research in the physical sciences in universities. An excellent example of this is support Innovate UK has provided a recent spin-out from Imperial College, Impression Technologies Ltd to develop a revolutionary aluminium forming process. It is playing a vital role as a weight-saving, low emission technology in the new Aston Martin DB11. It has been strongly committed to its support, and Edmonds expects that support to continue.

What really makes the UK most interesting however is the new Modern Transport Bill, which is set to create a framework enabling the UK to become a leader in driverless and electric technology. In order to really transform a market, a legal underpinning is required to allow technology to come to the forefront. This is especially critical for vehicles reliant on satellite connectivity, roadway sensors and the like – the question of liability is likely to become a heated discussion. By providing that framework ahead of the competition, and moving the UK forward in its development and deployment of new technologies, there is an opportunity for the UK to become a real world leader.

And, while there have been discussions about the impact of Brexit on the automotive sector, and the LCV market in particular, the government has announced it will support projects agreed under the EU’s Horizon 2020 programme. This matters because perhaps the most important aspect of such projects is the collaboration which they require.

That collaboration, between academics, scientists, engineers and industry has always been a hallmark of the UK automotive sector and one of its greatest strengths.
Electrification was early out of the blocks, hydrogen’s a bit of a late bloomer – and by 2050 many vehicles won’t even need drivers. Who can say what the automotive energy mix might be then?

Thirty something years into the future, traffic will move on “lanes with dedicated speeds of 50, 75 and 100mph, engineered for speed”. Safety will be resolved too, with vehicles segregated using “automatic radio control”. Sounds a bit familiar? No, it’s not the vision of Google, Tesla or Apple, but a General Motors concept called Futurama, exhibited at the 1939 World Fair in New York, an envisagement of what 1960s roads could look like. Nearly 80 years on, the science enabling cars to detect the proximity of other motors, people or things is still ironing out teething symptoms – a stark reminder that auto industry technologists have many hoops to jump through to catch up with the sector’s visionaries.

Present day imaginings of tomorrow’s automotive utopias have greener priorities. At March’s International Motor Show in Geneva, Nissan, in collaboration with architects Foster + Partners, presented the answer to the question: “What is the fuel station of the future?” Revealed in a futuristic three minute video clip, Nissan’s concept promotes its LEAF electric car as the hub of a zero emissions metropolitan lifestyle where, “charged by the sun, wind and the oceans, cars could empower people to store, and then distribute, renewable energy”. Overnight, cars autonomously swap around with other cars in the “smart street” to top up their batteries in wireless charging bays. In the morning, “your house and the grid draw energy straight from your car, powering your home as you start the day.” Nissan’s vision also extends into the workplace, where an automated parking system whisks your car away, “to be recharged – or the battery could even be used to power your office”.

To fulfil that dream, Nissan is exploring the symbiosis between energy infrastructure and vehicles, with current trials in Europe of a vehicle to grid system that, “will allow drivers to operate as individual ‘energy hubs’; able to store, use or return clean energy to the grid.”

“Development in batteries has been staggering – five years ago the idea of an electric bus, let alone an electric double decker, would have sounded impractical”, says Celine Cluzel, associate director at low carbon energy consultancy Element Energy. “Now entire bus routes are being converted to pure electric powertrain, notably in London, in demanding operating conditions. The value of the integration with the wider energy system – energy storage, grid services to support renewable generation, and optimisation of electricity demand profiles – will present great opportunities for both plug in and hydrogen–electric vehicles.”

However, he acknowledges that the move to electric, “will be less so for HGVs, other than buses”. But what about “range anxiety”? Consumers fret that they’ll run out of power or won’t be able to access charging points when needed – and don’t fancy waiting 30 minutes to top up batteries. There’s no such anxiety at Daimler Trucks, however, where the Mercedes Benz Urban eTruck – the first fully electric truck with an admissible total weight of up to 26 tonnes – could be on the roads as soon as early next decade. Similarly, Tesla’s Master Plan, Part Deux” maps out a future product line that includes the Tesla Semi, an electric autonomous heavy duty truck.

“By 2050, we anticipate electric vehicles will replace a considerable volume – if not the majority – of cars on the road,” says Simon Crowfoot, MD of Ecotricity’s Electric Highway, the vehicle charging network that covers most of Britain’s motorway network. “Electric vehicle ranges will increase, charging speeds will improve and costs will come down. While the infrastructure costs will still be considerable, they’ll be far less than alternatives, because the electric grid is already mature and embedded.”

But with policy advisers remaining neutral on technology platforms, and manufacturers focused around product and infrastructure, is consumer behaviour adequately accounted for in the equation? “Just take London,” says Adam Chase, director of Ettech, a strategic sustainable energy consultancy that collaborated on the Advanced Propulsion Centre’s Low Carbon Automotive Propulsion Technologies report. “If London’s low emissions zone extends significantly, that’s the point at which you’ll find people saying: ‘Well, do I want to own a car? Can I make better use of car sharing schemes or mobility as a service?'” With Volvo and Uber’s announcement in August of a $300 million joint venture to develop the next generation of autonomous cars, some interesting business models could come into play.

Chase maintains that, “If you layer on technology and autonomous capability, where it gets to be game changing, because that’s where the vehicle as we think of it as a privately owned motor car just ceases to be relevant”. With increasing purchase costs, insurance, parking and zone charges, ownership starts looking like a more and more onerous option where new entrants come in. “You don’t have to be a car company to build a lightweight two seat urban vehicle, which is why Google and Apple are such a threat to the industry,” Chase says – albeit the automotive aspirations of these companies remain shrouded in speculation.

But what does mean is that mobility as we know it might be disrupted, new ownership paradigms and disruptive upstarts will influence auto manufacturers as they strategise over the types of vehicles consumers will want – and that society will need – in 2050. These factors will most certainly be the determinants of the energy mix.
Opinion piece:

THE INNOVATION GAME

By David Moss, Vice President, Vehicle Design and Development, Nissan Technical Centre Europe

The UK government has committed to an 80 per cent cut in greenhouse gas emissions by 2050 (from 1990 levels). At Nissan, we have already reduced overall CO₂ emissions by 36 per cent by modernising the design of the internal combustion engine, and by bringing clean technology such as electric vehicles (EVs) to market.

At Nissan we’ve done a great deal of work on downsizing the turbo engine, as well as improving on aerodynamics, to help improve efficiency levels. We have achieved more power, with fewer CO₂ emissions and less fuel consumption, all while ensuring the aspect of fun in driving remains constant.

One of the key areas that we need to work on as an industry is weight reduction. This is a huge issue for the automotive sector and, while it is indeed possible, it’s proving a challenge to implement for the mass market. We produce a vehicle every 30 seconds, so there are huge efficiency gains to be made, however, it’s proving hard to make aluminium economic as a production material for such a process. Carbon fibre could also be a viable alternative - the UK has some of the world’s leading experts in its use through our work in the Formula One arena, so involving this technology in a mass production environment is clearly worth investigating.

The potential of advancements in fuel cell technology is another interesting field. At Nissan, for example, we’re already working on the development of fourth generation hydrogen fuel cells, while making advances in research around solid-oxide cells fuelled by ethanol converted from materials such as sugar cane. In international markets in particular, this could be of major interest, as many regions already have an infrastructure in place for the distribution of ethanol as a fuel.

Often, infrastructure – or lack of – emerges as a major barrier to innovation in alternative fuels, as proven with the lack of readily available refuelling points for hydrogen cells.

There is no question that the EV market is picking up and we’re seeing a much more rapid growth trajectory. We introduced our first fully electric vehicle in 1947, and, since 2010, have produced 220,000 of our latest vehicle, the Nissan LEAF, of which 50,000 are in Europe. To date, we’ve spent roughly £2.2 billion developing our EV capabilities, which represents a significant proportion of our overall R&D budget. This investment has enabled us to take the LEAF from an initial range of 109 miles (covering the majority of daily commutes in the UK) to 155 miles today.

We believe in providing a range of solutions to meet customer needs. While we already produce two vehicles which meet the targets required for the government’s Ultra Low Emission Zones, we’re also doing significant work in the infrastructure space. Beyond production of the fully electric Nissan LEAF and e-NV200 LCV, we’ve announced a major partnership with energy provider Enel to trial vehicle-to-grid technology across Europe. This latest development will turn electric vehicles into clean mobile energy units, able to put energy back into the grid as well as take from it.

We also have plans to move into the residential home energy storage market, with the launch of our ‘xStorage’ unit in Europe later this year, in partnership with power management firm, Eaton. The system will not only give Nissan electric vehicle batteries a ‘second life’, but will also provide a fully integrated energy storage solution that will put energy management and distribution back in the hands of the consumer.

We’re not only here to research and develop vehicles for the European customer, however – we’re here as a satellite for global operations. So when it comes to research, we want the best, and that means understanding what the UK has to offer in terms of talent and facilities. With the Automotive Council providing strategic insight to the government, we ensure that the research taking place across the UK is guided and heading in the right direction. That translates as clarity for suppliers, both large and small, which in turn means that we have a viable sector in operation across the board.

As an industry, we face a number of challenges ranging from congestion, to traffic accidents, and up to macro events such as climate change. Technologies such as EVs, autonomous driving, and connected vehicles, can together go some way to solving these issues. The UK has proven itself in terms of world-leading capabilities in R&D across these fields, and with collaboration between industry members and the government, the future for sustainable development looks bright.
INVESTMENT OPPORTUNITIES

FOCUS:
UK could provide focused support to build upon existing advantages in these attractive opportunity areas

- Provision of vehicle system integration services to high and low volume vehicle manufacturers and Tier 1 suppliers
- Application and systems engineering services for next generation traction electric machines and associated power electronics technology focusing on low volume and specialist applications, in addition to in-house activity conducted by high volume vehicle manufacturers’ R&D centres in the UK
- Development of improved exhaust aftertreatment and Tier 1 supply of high value aftertreatment sub-systems (including catalysts) to Tier 1 exhaust systems suppliers
- Development and supply of low cost, shorter cycle time lightweight components, focussing at least initially on the low to mid volume requirements of domestic UK vehicle manufacturers
- Provision of research and development services to lower volume and specialist vehicle manufacturers, leveraging advanced design and process techniques to deliver affordable lightweighting solutions

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<td>Research, development and low volume manufacturing leading to licensing of next and next + 1 generation battery cell chemistry</td>
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INVEST TO IMPROVE:
UK could invest to improve positioning since these opportunities appear to be attractive

- High volume manufacturing of electric traction machines by vehicle manufacturers (and/or Tier 1 suppliers) generating demand for Tier 2 supply of components and/or sub-assemblies
- Development of new sustainable lightweight materials that are low cost, low embedded energy and recyclable, with commercialisation via licensing to established material producers

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OPPORTUNISTIC:
UK has good positioning for these opportunities, though their relative attractiveness is lower. The UK could take advantage of its position as opportunities emerge

- Development of advanced boosting solutions, with commercialisation via in-house development by Tier 1 suppliers with a UK footprint and/or intellectual property licensing to Tier 1 suppliers without a UK footprint
- Development and Tier 1 supply of integrated fuel cell systems to low volume vehicle manufacturers
- Development and manufacturing of cost effective hybrid electric recovery systems, primarily for bus and off-highway applications

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<td>Development and Tier 1 supply of novel propulsion and auxiliary power engines to niche and specialist vehicle manufacturers to comply with emissions regulations and sustainability commitments</td>
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- Development and licensing of innovative solutions to established transmission manufacturers (vehicle manufacturers and Tier 1 suppliers) for integrating the traction electric motor, transmission and driveline in electrified powertrains
WHY THE UK IS AN AUTOMOTIVE LEADER

The UK’s collaborative R&D approach has led to huge advances in LCV development, says Dr Graham Hoare, Chairman of the Automotive Council Technology Group and director of Global Vehicle Evaluation and Verification at Ford.

The UK is a key player in the world of low-carbon vehicle technology for a number of reasons. It has a world-class scientific and engineering base, strong R&D and a very interesting collection of companies, all of which complement one another. While these companies are fiercely competitive in their own markets they can join together to solve common industry and technological problems.

It helps that while the competitive landscape is strong, many of the companies are targeting different sections of the market, or have very different brand identities. Ford in the UK, for example, is strong in powertrain development and engine manufacturing, with a focus on the engineering of commercial vehicles. Jaguar Land Rover doesn’t really compete in the same space, as it’s targeting a luxury 4x4/premium market. Aston Martin competes in the high-end luxury market but it, in turn, is a very different brand to Bentley.

This means the UK provides an environment for companies to operate as world-class competitors but in a spirit of complementarity, with an ability and desire to work together to improve the automotive sector as a whole. By contrast, in other countries and regions there is a much more direct competitive landscape, where automotive companies are all targeting similar markets and delivering similar products.

Perhaps the most significant reason however, is the engagement of the UK Government. The Government is as much part of the campaign for a stronger automotive sector in Britain as the industry itself, as it recognises the role of the automotive industry as a catalyst for, and contributor to, growth.

RECIPE FOR SUCCESS
That shared vision has been critical to the UK’s success and, despite concerns raised over the impact of Brexit, we would expect that to continue. We know things are going to be different but there is a real recipe for success in Britain and we need to continue to strengthen that approach.

In the UK, we had huge success in collaborative R&D through Automotive Council led initiatives. We have identified the challenges we need to address (in terms of air quality, CO2, solving thermal efficiency issues and the broader agenda of mobility) and how low-carbon and autonomous vehicles will evolve in the future.

In collaboration with the government, we created the £1 billion Advanced Propulsion Centre as a central part of the Automotive Council’s industrial strategy, and which is expected to drive growth of 30,000 new jobs in the industry.

It is the Advanced Propulsion Centre which is now working on how we address these challenges, through the following strategic technology areas: lightweight vehicles and powertrain structures, electric machines and power electronics, energy storage and energy management, and internal combustion engines.

HUB AND SPOKES
Part of the process is to help universities engage throughout the value chain, through the Advanced Propulsion Centre’s model of Hub and Spokes. The Advanced Propulsion Centre “hub” is located at the University of Warwick, with “Spokes” as centres of excellence throughout the UK, providing a coordinated national resource of facilities and expertise. They are designed to provide access to the best expertise and facilities the UK has to offer in key strategic technologies for the automotive industry.

Each Spoke is developed through a collaboration, creating partnerships between those who have good ideas and those who can bring them to fruition.

In London for example, the partnership includes Ford, McLaren, Cosworth, Ricardo, AVL, the High Speed Sustainable Manufacturing Institute (HSSMI) and Autodesk. Loughborough University, University College London, the University of Bath and the University of Nottingham.

We need to continue to enhance the UK ecosystem and the Automotive Council technology agenda as we push the boundaries of technology, for low-carbon, clean propulsion and especially in relation to autonomous and connected vehicles. In the areas of mobility systems, autonomous vehicles and embedded controls, I’m sure there are some game changers awaiting discovery.

The UK is recognised and appreciated globally as an automotive leader, and now is the time to be even stronger, helping both domestic automotive companies and those headquartered overseas to find new ways of working together to drive our industry forward.
Lucas di Grassi of Brazil and ABT Schaeffler Audi Sport celebrates by skidding his car after winning the Mexico City Formula E Championship 2016.
The fundamental conclusion of the Advanced Propulsion Centre’s Capability Report is that the UK is great at innovation. This was also recognised in the recently released Global Innovation Index 2016 (GII 2016), which measures the level of innovation within a country, where the UK came after only Switzerland and Sweden. What the GII 2016 reports is that a corporate innovation culture built around novel partnerships and innovation platforms has significant potential to drive long-term economic growth. It highlights the central importance of investment in research and development (R&D) and innovation for economic growth. Countries that consistently perform well in the index, or show improvement in innovation performance, are all making R&D spending and innovation key priorities.

Developing and maintaining an innovation culture is a challenge nonetheless. Establishing innovation systems with solid innovation inputs, sophisticated markets, a thriving business sector and robust linkages among innovation actors is a complex process. This is where the UK automotive sector stands out – the unique strategic alignment between industry and government. Not only does it host bodies such as the Automotive Council and the Advanced Propulsion Centre, providing strategic guidance and funding for applied development, but it benefits from specific automotive programmes within Innovate UK and the Catapult. On top of that, the government also offers a range of tax incentives, grants and loans to organisations taking part in R&D. Its continual investment in education, national infrastructure and business support provides a softer measure of its innovation backing.

The UK has an outstanding tradition in producing the very best in science and research – with less than 1 per cent of the world’s population, the UK produces 16 per cent of the top quality published research. This is despite a relatively small investment – as a share of total GDP, investment in innovation was just 1.67 per cent in 2014. Yet China and the US far outstrip the UK in terms of patent filings, even in a period which has seen patent filings increasing by up to 500 per cent. What this suggests is that the UK is not taking full advantage of the UK automotive opportunity.

The Capability Report, led by Advanced Propulsion Centre’s Chris May who as project leader managed industry collaboration in the sharing of sensitive data, is very clear that the UK is in a position to take global leadership in a number of areas – lightweight technologies, traction batteries, traction electric motors and power electronics - but that it must act now to address the challenges it faces. It is likely that there will be significant technology-led disruptions to incumbent supply chains over time, a unique opportunity for the UK given its relative lack of Tier 1 suppliers compared with other leading automotive nations. The recent resurgence in the UK’s domestic vehicle manufacturers is creating a window of opportunity for the UK supply chain, but the competition is fierce and the UK needs to act quickly if it is to take advantage of that chance. The supply chain must collaborate to offer competitive products and services that can challenge the incumbent Tier 1 supply chain positions.

Global competition is fierce, and emerging economies like China (which joined the GII for the first time this year) are only increasing that competition. The UK must evolve with this new reality, driving its competitive advantage by transforming the UK’s ability to deliver increasingly complex and rapidly evolving technology systems across the supply chain.
The UK grid, in common with many, needs more electricity storage capacity to balance supply and demand, chiefly because variable output renewables – such as wind and solar – form an ever greater part of our energy system. Were every domestic vehicle in the UK electric, the equivalent of several large power stations would be potentially available. Harnessing this capacity could allow grid and domestic renewable output to be maximised without impacting grid stability by either absorbing excess capacity, disconnecting from charging during peak load periods or supplying power from storage when required.

Such a scenario could perhaps see the owners even paying for their EV charging costs by making storage capacity and other grid-balancing services available with smart, grid-connected EVs. And after all, most domestic vehicles spend the vast majority of the time parked.

This type of smart use of EVs as an energy storage asset is already under trial in Denmark by Nissan. As Dunsmore observes: “It puts the user in control. Energy is becoming a shareable economy with vehicle-grid technology.”

In the nearly two decades since Toyota launched its pioneering Prius hybrid electric, in 1997, technology across a whole range of allied and supporting low-carbon vehicle industries has advanced dramatically. Lightweight materials, fuel cells and batteries, transmission and traction, engine management and catalysts, all have a role to play in determining the future of low-carbon transport. The ultimate technology winners will offer consumers what they want.

The cost, convenience, usability and control advantages necessary to supersede their fossil-fuelled forerunners is currently being fought across a number of fronts.

Both fuel cells and batteries have advantages and both face challenges in establishing appropriate infrastructure that will facilitate that crucial usability consideration.

Professor David Greenwood at WMG, The University of Warwick, explains: “We would need an infrastructure in place to support either. The difference is that there is already an electricity infrastructure in place which can be reinforced and strengthened, whereas there isn’t currently a hydrogen infrastructure in place.”

This is a point echoed by Gareth Dunsmore, EV Director for Europe at Nissan UK. “It’s very easy infrastructure with electric vehicles in some ways, every single plug in the UK can charge an electric vehicle, whereas hydrogen of course has that great challenge, but perhaps in the future, one day that might be cracked.”

Advances in battery technologies also threaten to erode the fuel cell’s advantages of superior range and quick refills.

According to Greenwood: “The niche that fuel cells fill is that of a vehicle that needs to be re-fuelled relatively quickly in order to be able to travel long distances, if we get to the point where batteries are able to hold the amount of energy required to do that and are able to fast charge very quickly and efficiently then that’s eroding the market that fuel cells would be looking to exploit.”

There is at least another decade or more of both cost and performance advances anticipated in the lithium-ion technology that powers the current generation of electric vehicles. Furthermore, a host of potentially attractive battery chemistries are currently being explored and developed with some success. For instance, lithium iron phosphate and nickel cobalt manganese are chemistries which are already in commercial use and though no small challenge to scale-up to commercially viable systems, promising technologies at an earlier stage of development also include sodium-ion, lithium-sulphur and lithium-air as well as solid electrolyte technology, also referred to as solid state batteries.

As Dunsmore notes: “I think over the next three or four years, we’re going to see huge advancements in the range so that range limitations suddenly becomes a thing of past. That is the most exciting next step.”

Fuel cells also have another potential advantage though. In August Nissan revealed its prototype solid-oxide fuel cell vehicle, an iteration of its e-NV200, which uses reformer technology to produce hydrogen from liquid fuels – in this case widely-available ethanol. Currently undergoing field tests on public roads in Brazil, the vehicle is expected to have a range of more than 600 km.

Although reformer technology will inevitably add cost, complexity and potentially weight, it does address a big chunk of the infrastructure equation.

“We’re focusing just on trials at the moment in Brazil, but potentially you could buy this fuel from any petrol station, or any liquor store,” says Dunsmore. Major auto manufacturers are nonetheless pushing hard for better access to quick charging infrastructure, for example exploring on-street parking for urban areas using ‘smart’ lamp-posts which have charging facilities.

Also under development to facilitate ease of charging for battery vehicles is wireless power transfer (WPT). Currently commercially available as a static system, in which the vehicle is parked over an inductive pad – dynamic, on-the-move, charging technology is also potentially on the cards.

Dunsmore highlights the role that city municipalities could play in rolling out WPT, for example through bus-lane charging systems: “If that sort of infrastructure is put in place by municipalities, it suddenly makes wireless charging for electric vehicles that people own as personal mobility something of use and the value would be phenomenal.”

Looking forward further though, an even greater environmental and economic opportunity for EV will perhaps emerge.

WHAT MIGHT HAPPEN?
Looking Forward

The Advanced Propulsion Centre’s recent capability study explicitly concludes that the UK has a tremendous opportunity to capitalise on the transformation of the transport sector by building on its strong capabilities in areas such as lightweight materials, traction batteries and a host of allied fields. However, more work is required to attract the needed inward investment and realise this huge potential to forge the future of transportation. Transport is changing. Indeed, it’s no great leap of imagination to consider that children born just a few decades from now may find the phrase “roaring traffic” as anachronistic as VHS video tape recorders are to the PlayStation generation. Instead, their urban world will be filled with the faint hiss of tyres on tarmac and the whisper of moving air.

While global internal combustion engine manufacturing and sales may peak in the coming years, there is a huge tail of need from heavy-duty applications such as buses and trucks and long-distance vehicles. Hybridisation will play an important role, especially for long-distance travel.

Evolving Strategy

With environmental considerations indicating that the supremacy of electric vehicles is all but assured in the future, questions still remain over which low-carbon technologies will emerge to transform the transport sector and which players will stand at the top of the LCV market. The UK must evolve with this new reality. As Ian Constance, chief executive of the Advanced Propulsion Centre says: “There is a lot of activity in almost every area but most companies can’t afford to back all the horses in this race. If they select one technology now, it may be too early.”

That is what the ecosystem driven by the Advanced Propulsion Centre and Innovate UK is setting out to achieve, the ability to do more with less, and to take fewer risks. According to Constance: “The capability report is a key aspect of what we do, and we’ll be doing one every couple of years. It means we’re making sure we’re constantly monitoring our environment and evolving our strategy. It means we can keep on top of the trajectory of travel and inform the roadmaps we create. And it means we can go on that journey together.”

In one key conclusion, the report notes that to attract further investment and secure more export opportunities, UK organisations need to be widely recognised as leading the world in specific and significant areas of technology.

Professor David Greenwood of WMG at the University of Warwick says of the study: “It looks at lightweighting of vehicles and concludes that we’ve got some really good experience, particularly in areas such as motor sport. It looks at electric motors and power electronics and concludes that we’ve got some really good capability. We’ve got an extremely strong academic base developing new battery technologies and battery chemistries.”

Fierce Competition

However, while organisations operating in the UK can build upon world-class research, development and manufacturing capabilities to capitalise on these technology-led disruptions, international competition is fierce. Furthermore, investment barriers are still to be overcome to maximise the potential gain; for example, the UK lacks many global tier one suppliers. As a result, the UK supply chain must collaborate to offer competitive products and services that can challenge the incumbent tier one supply chain positions. Disruption of incumbent supply chains is always a potential threat, but it also provides an opportunity for organisations willing to embrace change.

Greenwood concludes: “I think the key message that comes forward from the capability study is that we have to recognise that cars aren’t going to look the same in 10 or 20 years’ time, that the UK is extremely well placed to have an active part in delivering those future transport solutions and that there is a really good alignment between government policy-makers and UK manufacturers to deliver against those objectives.”

What the UK needs to do is look forward and build on its strengths. The UK automotive sector is strong, and growing, but, as Constance says: “We need to step on the gas.” The capability report demonstrates that both the ability and opportunity for LCV is in no short supply for the UK. As the world shifts from current-generation technology to the next the UK needs to be at the forefront of that change. All that’s needed is the will to ensure that capability is realised.

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Building on its strengths in automotive development, the UK is at the forefront of change in the transport industry, as it adapts to global advances in technology.
INNOVATION
AND R&D ECOSYSTEM

FUNDERS

Department for Business, Energy and Industrial Strategy (BEIS)
The new Department for Business, Energy and Industrial Strategy (BEIS) brings together responsibilities for business, industrial strategy, science, innovation, energy and climate change.

Business and Energy Secretary Greg Clark said: “Our automotive sector continues to go from strength to strength, thanks to our highly skilled workforce and long-term investment in new technology and innovation. This Government’s comprehensive industrial strategy will build on that success, ensuring that we have the right infrastructure, skills and support in place for our world-leading industries, as well as support for new emerging sectors to flourish.”

Department for International Trade (DIT)
The Department for International Trade promotes British trade across the world to ensure that the UK takes advantage of the opportunities available for trade. It does this through developing, coordinating and delivering a new trade and investment policy to promote UK business across the globe; developing and negotiating free-trade agreements and market access deals with non-EU countries; negotiating plurilateral trade deals (focused on specific sectors or products); and providing operational support for exports and facilitating inward and outward investment.

The Engineering and Physical Sciences Research Council (EPSRC)
The Engineering and Physical Sciences Research Council (EPSRC) finances research discovery and innovation. It is the main UK government agency for funding research and training in engineering and the physical sciences, investing more than £800 million a year in a broad range of subjects – from mathematics to materials science, and from information technology to structural engineering.

The EPSRC is a non-departmental public body funded through the Science budget by BEIS. Regarded by many as being one of the best-aligned government funding mechanisms in the world, it has a £4.6 billion research portfolio, of which 84 per cent is collaborative with over 3,550 organisations.

Automotive Investment Organisation (AIO)
The Automotive Investment Organisation was formed in 2013. It forms part of DIT and is strategically aligned with the Automotive Council. The AIO aims to increase targeted foreign investment in the automotive supply chain and research and development, strengthen the Government’s links with global automotive HQs, and promote UK automotive industry.

Innovate UK
Innovate UK is the UK’s innovation agency. It works with companies to de-risk, enable and support innovation, putting them in a stronger position to attract investment, and facilitating access to investors, collaborators, customers and export markets. Since 2007, Innovate UK has invested around £1.8 billion in innovation, which has been more than matched by the private sector – returning between £11.5 billion and £13.1 billion to the economy. It has supported innovation in 7,800 organisations, creating around 55,000 new jobs.

Innovate UK’s Low Carbon Vehicles Innovation Platform was established in 2007 to support innovation in the LCV sector and help boost the UK automotive supply chain. Alongside Innovate UK, the programme of LCV support is also backed by the Office for Low Emission Vehicles and the Department for Business, Energy and Industrial Strategy. Nearly 300 innovation projects have been supported to date, involving over 700 collaborators from across the UK.

Office for Low Emission Vehicles (OLEV)
The Office for Low Emission Vehicles is part of both the DIT and BEIS. It funds and manages a programme of industry-led research and development to support emerging technologies which the UK can exploit and lead globally, where full commercial funding is not otherwise available. The Government is committed to accelerating the pace of change in ultra-low emission vehicle technology and contributes to the funding of a range of innovative research and development activities.

OLEV is focused on identifying and supporting emerging technologies in this area. These currently include: energy storage and management, electric machines and power electronics; light-weighting of vehicles; relevant industry disruptive technologies.
POLICY MAKERS
Department for Transport (DfT)
Department for Transport plans and invests in UK transport infrastructure. It has four strategic objectives:
- Sustain economic growth and improved productivity through reliable and efficient transport networks;
- Improve the environmental performance of transport;
- Strengthen the safety and security of transport; and
- Enhance access to jobs, services, and social networks, including for the most disadvantaged people.

The department "creates the strategic framework" for transport services, which are delivered through a wide range of public and private sector bodies including its own executive agencies.

Centre for Connected and Autonomous Vehicles
Centre for Connected and Autonomous Vehicles (CCAV) is a new joint policy unit between BEIS and DfT. It is intended to address the interaction among vehicles, infrastructure and data to achieve these technologies’ significant economic and social benefits. CCAV’s goal is to help ensure that the UK remains a world leader in developing and testing connected and autonomous vehicles by: leading and innovating policy development in this sector; delivering a programme of research, development, demonstration and deployment activity, worth up to £200 million, through Innovate UK, providing co-ordination across DfT, BEIS and the rest of government; and by being the single contact point for stakeholder engagement.

INDUSTRY AND ACADEMIC BODIES
Automotive Council
The Automotive Council was established in 2009 to enhance dialogue and strengthen co-operation between the UK Government and the automotive sector. The Council is made up of senior figures from across industry and government and meets three times a year. It provides strategic insight to government about opportunities for growth and development in UK automotive. The activities of the Automotive Council are channelled through three working groups, each divided into a range of work streams. The working groups are: business environment and skills; supply chain; and technology.

Low Carbon Vehicle Partnership (LowCVP)
The LowCVP which was established in 2003, is a public-private partnership working to accelerate a sustainable shift to lower carbon vehicles and fuels and create opportunities for UK business. Around 200 organisations are engaged from diverse backgrounds including automotive and fuel supply chains, vehicle users, academics, environment groups and others. The Partnership became a not-for-profit company limited by guarantee in April 2009.

Transport Systems Catapult
The Transport Systems Catapult is one of ten technology and innovation centres established and overseen by Innovate UK. It was created to drive and promote intelligent mobility, using new and emerging technologies to transport people and goods more efficiently and effectively. The main focus areas are automated transport systems, modelling and visualisation, customer experience, information exploitation and smart infrastructure.

Advanced Propulsion Centre
Spokes Communities
The Spokes communities are designed to provide access to the best expertise and facilities the UK has to offer in key strategic technologies for the automotive industry. Each of the Spokes is hosted by an organisation with recognised expertise in those key technologies, but the fundamental role of the Spoke is to coordinate a community of common interest. This community will act as a centre of excellence in the key technologies for the UK automotive industry.

The Spokes network brings together academia and industry to work collaboratively on fundamental and applied industrial research. It also provides a platform to engage the broader community in the key challenges that the sector needs to address.

The current Spokes are led by:
- Loughborough University (London): Digital Engineering & Test Centre
- Newcastle University: Electric Machines Spoke
- University of Bath: ICE System Efficiency Spoke
- University of Brighton: ICE Thermal Efficiency Spoke
- University of Nottingham: Power Electronics Spoke
- University of Warwick: Electrical Energy Storage Spoke

The Society of Motor Manufacturers and Traders (SMMT)
The SMMT is the trade association of the UK motor industry. It exists to support and promote the interests of the UK automotive industry at home and abroad. It acts as the voice of the motor industry, promoting its position to government, stakeholders and the media across a number of major themes:
- Competitiveness
- Education and training
- Consumer protection
- Environment
- Globalisation
- Legislation
- New Technology