

The Future of the Car

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Automakers spy hazards ahead

Technological and regulatory demands force manufacturers to invest as vehicle sales face difficult times, writes *Andy Sharman*

Imagine driving on a busy road surrounded by speed cameras while trying to programme the sat nav. And then the fuel starts to run out. Carmakers may feel they face a similar challenge today.

Governments worldwide are demanding progress towards lower emissions and higher safety standards. New entrants such as Tesla are disrupting traditional business methods. Meanwhile, consumers want cars to be a smartphone on wheels. And groups within and from outside the sector are racing to introduce autopilot functions.

At the same time, a more prosaic challenge has appeared: selling cars.

For months, signs have been growing that, after three years of improving fortunes, the outlook for global automotive demand has turned. Russia and Brazil have gone from emerging market darlings to demons, with sales down 13 per cent and 9 per cent in the year-to-date. India, too, has stalled. Europe, though improving, remains 20 per cent below the pre-crisis peak. According to analysts most new cars on the continent are sold at a loss.

Despite plant closures and job losses, European capacity utilisation remains stuck at an average 70 per cent, according to AlixPartners research, versus about 92 per cent in the US.



Shanghai express: although they have been responsible for 50 per cent of global vehicle growth since 2009, car sales in China are slowing – Aly Song/Reuters

The US, the world's second-biggest car market, is expected by researchers at JD Power to achieve record sales next year. But other analysts fear the market is nearing its peak, over-reliant on sub-prime auto loans and stalked by the spectre of a rise in interest rates.

And China, a region that has been responsible for 50 per cent of global car sales growth since 2009, is slowing.

Year-to-date sales are up by a relatively modest 7 per cent. The era of double-digit expansion in the world's largest car market seems over.

Harald Hendrikse, an analyst at Morgan Stanley, says: "This is coming at a time when cost headwinds from regulation and legislation are hitting the industry like never before.

"At the same time, manufacturers are

under pressure to come up with the car of the future, which requires a completely different level of investment."

How will the industry respond? Will innovation suffer in an environment where revenues are slowing and carmakers are being forced to cut costs?

There is mounting concern – even anger – among chief executives that in the current sales environment,

regulators are demanding a level of fuel performance that consumers are unwilling to pay for.

Pure electric cars, which are seen as necessary if carmakers are going to meet the EU target of 95g of CO₂ per kilometre by 2021 and avoid fines, are expected to account for less than 1 per cent of global sales for the rest of this

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FT.com video

Rohit Jaggi test drives the BMWi8 – a hybrid sports car that is fast as well as frugal

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The Future of the Car

Constant monitoring raises privacy and safety worries

IT and motoring

Rush to include cutting-edge technology in cars could be a security minefield as well as a boon, says *Henry Foy*

The car used to be one of the purchases that said the most about you. Today, it might be better to think of it as the thing that knows the most about you.

Drive a new car out of a showroom and hundreds of sensors, scanners and cameras begin tracking every aspect of your driving, as the car's communication systems link you to the outside world.

These systems make you safer and help you reach your destination more easily. But they also open up previously unreamed-of revenue streams for car-makers, insurers and telecoms companies. And they present a privacy and security minefield.

"Data transmitted from a connected car could tell someone a lot about the driver," says Prasad Satyavolu, head of

innovation at Cognizant Technology Solutions. "How fast [and how well] they drive, where they are, what routes they take, what times they typically drive, even what music they listen to."

Mr Satyavolu, whose company builds connected car systems for a range of manufacturers, says: "There are benefits to carmakers and insurers from the data, but with consumers more aware of data privacy than ever, it is important that there is transparency on which data are shared, with whom and why."

Electronics appeared on the dashboard in the 1930s with the first in-car radio and cassette players arriving 30 years later. General Motors introduced emergency services monitoring systems in 1996, while satellite capability first appeared commercially in the 1980s.

Today's cars can boast iPad applications, full mobile communication systems, and technology that allows for complete remote monitoring of telemetry and component status, such as engine temperature or reporting a broken windshield wiper.

That means drivers can check their emails, stream music, call home and

spot the nearest McDonald's, while also benefiting from safety alerts, fuel efficient route recommendations and automated scheduling of parts servicing.

GM is now leading the rollout of camera technology that can track eye movements and spot distracted drivers, while Ford is close to commercialising car seats that detect potential heart attacks.

'A car thief can open some of the most modern cars just by using a computer and radio equipment'

Having access to data from cars could be lucrative for almost all in the automotive revenue chain. Carmakers could use in-car data to see which functions are used and those that are ignored, helping them fine-tune future features.

Insurance companies could find out how safely cars are driven, or tailor policies according to how often a car is serviced. The number of insurance policies in the UK tied to telematics, or a

monitoring device in the car, trebled between 2011 and 2013 to 300,000.

Advertisers could also use time and route information to discover what offers would be most relevant to drivers.

"As long as consumers have the ability to opt in and can see the benefits of sharing their data, and manufacturers are putting in place measures to anonymise and store data safely, then it should be down to the individual to determine the line between cost savings and their data use," says Mr Satyavolu.

The demand seems to be strong. According to a survey of developed car markets by Accenture, 56 per cent of drivers would like to read and dictate emails while at the wheel and 52 per cent want cars that identify traffic signals, accidents and traffic congestion.

The pace of innovation - and a race between carmakers to be seen as the most cutting-edge - has pushed forward the implementation of always-connected technologies into today's cars, while regulators have encouraged their adoption for safety reasons.

The EU has implemented rules mandating the installation of an "eCall"

system in new cars by the end of 2015, which wirelessly sends airbag impact sensor data with GPS information to emergency services if there is a crash.

The eCall system will mean that wireless information gathering tools will be installed in almost 7m cars in Europe by 2016, according to research from the GSM Association of mobile telecom companies.

The other side of the boom in wireless communication technology in cars concerns security. Hackers have shown that communication systems, such as tyre sensors, can be accessed and used to control other parts of the vehicle.

"Currently, there is little or no security in cars," says Gary Newe, director of field systems engineering at F5 Networks, a data networking and security company. "A car thief can open some of the most modern cars without a key, just by using a computer and radio equipment."

He adds: "The fact we are starting to connect these cars to the internet, and share data between consumers, manufacturers and others, should concern everyone."

Introduction of automatic braking will save lives

Crash prevention

Improvements to vehicle safety are seen as a big contributor to the reduction in fatalities in the EU, reports *Jane Wild*

A car is travelling down a road but the driver has not noticed the van ahead is stationary. Moments from impact, cameras on the moving vehicle detect the obstacle and automatically activate the brakes, avoiding a collision.

The system that prevented the crash is autonomous emergency braking and it is being hailed by safety experts as the greatest new technology in motoring.

Improvements to vehicle safety are seen as one of the big contributors to the reduction in road deaths in the EU over the past few years and crucial to its target of halving fatalities between 2010 and 2020. There were more than 26,000 deaths on Europe's roads last year and some 199,000 people were seriously injured - a stark reminder that more must be done to reduce those numbers.

The European Transport Safety Council recommends that autonomous emergency braking becomes mandatory when the EU revises its vehicle safety requirements in the next year.

The organisation is also pressing for the compulsory introduction of intelligent speed assistance - which tells drivers when they are breaking the speed limit - and seatbelt reminder warnings. The costs of introducing such technologies drops when they become mandatory, says the ETSC.

In Sweden, which has the world's safest roads, deaths plunged by 59 per cent between 2001 and 2012. One of the reasons was that the majority of new cars sold had a top, five-star, safety rating, says Ellen Townsend, policy director at the ETSC.

At present, autonomous emergency braking is fitted on only a small percentage of cars. In the UK, it is fitted on 29 per cent of new vehicles, slightly ahead of the European average, according to Thatcham, a motor research centre based in Berkshire, England.

Vehicle makers say the path to road safety is an "integrated approach", combining better vehicles with improved driver training and input from the road planners. But it is also true that road safety has been a hallmark of the European project.

"As a whole, the EU is doing well, but to reach the 2020 target, we're going to need a lot more effort, especially in the less well-performing countries," says Ms Townsend.

Countries lagging behind include Romania and Estonia. Overall, however, road deaths across the EU fell by 18 per cent between 2010 and 2013. Most improved was Slovakia, which reduced road deaths by 37 per cent between 2010 and 2013.

The political will to make changes is vital to success. Once politicians are motivated, it needs only three or four road safety measures to see figures improve, experts say. Those might be more intelligent road layouts, a penalty points system to encourage safer driving and better law enforcement.

Nobody wants to provide an estimate of the costs of implementing road safety measures. Instead, those working to save lives prefer to focus on the sums saved by avoiding deaths, estimated at

Hydrogen and electric vehicles battle for supremacy

Infrastructure A shortage of recharging points threatens new technologies, writes *Andy Sharman*

Jaguar Land Rover attracted the attention of global media last month when Queen Elizabeth II opened its £500m factory in Wolverhampton, a homage to the internal combustion engine.

On the same day, Honda held a party in Swindon to celebrate an alternative technology, when it opened the UK's first commercial-scale, solar-powered hydrogen refuelling station.

The Japanese carmaker opened the site, capable of producing 20 tonnes of hydrogen a year, in an attempt to kick-start the adoption of ultra low-emission cars in the UK.

Drivers have been put off hydrogen fuel cell and electric vehicles because of their cost and by fears they may become stranded with nowhere to fill up.

Battery electric vehicles struggle to match the single-trip mileage of a petrol or diesel car. While hydrogen vehicles can achieve better distances, refuelling options are so limited that the technology is considered to be still in the demonstration phase. This lack of infrastructure is at the heart of the industry's drive to find a way to power cars in the future while meeting demands for lower emissions from global regulators.

"I hate the phrase 'chicken and egg', but it explains the problem perfectly," says Robin Hayles, sustainable fuel

development manager at Korean manufacturer Hyundai. "There's no point in having the stations if you haven't got the cars, and there's no point having the cars if you haven't got the stations."

Hybrid vehicles have had some success - particularly in Japan, where they account for one in every five new cars sold, according to auto parts maker Bosch. But pure electric cars are still expected to make up less than 1 per cent of the total vehicle market by 2020.

A survey by PwC of 1,500 car buyers in Germany, France and the UK found about 99 per cent would not consider buying an electric car. There are only a handful of hydrogen fuel-cell vehicles on Britain's roads, so any infrastructure put in place would be serving future needs not meeting existing demand.

"Local authorities don't want to be seen to be 'wasting money' on chargers [and fuelling stations] that may well not be used," says David Bailey, an automotive expert from Aston Business School. But there are signs that momentum is gathering behind both zero-emission technologies.

A new generation of electric vehicles is now on the roads, in the form of the BMW i3, the latest Nissan Leaf and the Model S from premium carmaker Tesla.

The Californian company set up its own infrastructure to support custom-

Getting connected: a Tesla Model S is plugged in outside the company's factory in California

Justin Sullivan/Getty Images

ers. Tesla has installed 128 supercharging stations in the US, capable of a 50 per cent charge in 20 minutes. Europe has 87 Tesla superchargers and there are 34 in Asia. The company has agreements to install a further 500 chargers in China alone, says ISI Automotive Research.

Arndt Ellinghorst, head of global automotive research at ISI, says: "Tesla and its owners are a testament to the fact that the private sector can and should support the necessary infrastructure, alleviating private and public sector investments in costly hydrogen networks."

Alternative infrastructure options are also emerging for public transport. Cities from Málaga to Milton Keynes have tested dynamic inductive charging lanes for buses, which allow the vehicles to be refuelled wirelessly.

Similar technology being pioneered by tech group Qualcomm will be used in Formula E, the electric car racing championship, to charge vehicles in the pits.

Hydrogen cars, too, are improving. Hyundai last month launched the first series-production fuel-cell vehicle (FCV), the ix35. Toyota, which appears to be stepping back from its partnership with Tesla, has also pledged to launch Mirai FCV in the UK, Germany and Denmark in 2015.

Governments in Europe, the US and

'Local authorities don't want to be seen to be "wasting money" on chargers'

Younger generation moves away from owning a vehicle

Car sharing and hire

With cities becoming more congested, schemes are expected to expand rapidly, reports *Gill Plimmer*

From next March, Londoners will be able to book electric cars using mobile phones and smart cards.

The "car sharing" venture is the dream of French billionaire tycoon Vincent Bolloré and is based on the success of the Autolib's scheme in Paris. The London scheme will allow drivers to use a car for £5 for half an hour, plus a £5 monthly members fee.

The idea - which is being supported by Transport for London, the body responsible for most public transport in the UK capital - underscores just how rapidly car-sharing schemes are being rolled out worldwide.

With urban centres becoming increasingly congested, car sharing is expected to expand quickly over the next decade, particularly in cities that

are being forced to review the car as the dominant means of transport.

According to Frost & Sullivan, a consultancy, membership of so-called car-sharing organisations grew by about 50 per cent in 2013, providing transport for 3.5m members using 70,000 vehicles worldwide. The consultancy estimates that membership will grow by a further 43 per cent this year and hit the 5m mark, while vehicle numbers will increase by a third. The top car-sharing countries in 2013 were the US, with 1.05m car-sharing club members, and Germany, with 760,000.

Zipcar, which claims to be the biggest car-sharing club in the world, said last summer that it had more than 800,000 members worldwide.

Similar services are expanding elsewhere. Kandi Technologies opened an hourly car rental service in Hangzhou, China, this year, and Comos, an electrical car service, is already operating in Malaysia.

Chas Ball, chief executive of Carplus, a British lobby group, sees car sharing as a complement to other environmentally-friendly modes of transport such as

walking, cycling, buses and trains. "There are many times you need a car, but you don't need to own one. If the system allows you to book one - almost using the system [as though it were] public transport - it becomes a complementary system," he says.

He points to research showing that any city where 30 per cent or more of trips are done by car makes "getting around less pleasant". "Public transport doesn't run so freely and you are consequently hitting deadlock," he says.

The increase in car sharing comes at a time when car use per capita is falling after nearly 80 years of growth. David Metz, author of *Peak Car: The Future of Travel*, says the number of journeys by cars in most developed countries is declining, creating opportunities for car sharing. "The world is experiencing a shift away from cars in successful cities. This creates opportunities for car sharing, particularly for people who don't need a car all the time."

Although car sharing is open to all, take-up has been greatest among younger, technology-savvy people in high-density cities such as Seattle, New



Zip code: car sharing is taking off

York and Montreal. "It's wrong to characterise it as a young people's service, but they are the early adopters," says Mr Ball. "They need a smartphone more than a car and it seems that they are just not as excited about owning a car and sometimes not able to afford it."

In the US, for example, people aged 55-64 were found to be more likely to be buyers of new cars than drivers aged 35-44, according to a University of Michigan study of sales from 2007-11.

As with other forms of the shared

economy - such as Airbnb, the internet app that allows homeowners to rent out spare rooms - car sharing is shaking up traditional transport industries. Rail operators such as Deutsche Bahn, the German train company, have pushed the boundaries and formed partnerships with a wide range of car and bike-sharing schemes at railway stations.

Meanwhile, car manufacturers have also invested in car sharing schemes. Daimler's Car2go operates in about 30 cities, while Peugeot Citroën, BMW and Volkswagen have also entered the market. Traditional car-rental companies have introduced car-sharing services, including Hertz and Uhaul.

However, variations are constantly emerging. EasyCar Club, the creation of Sir Stelios Haji-Ioannou, founder of the easyJet airline, and Brent Hoberman, the lastminute.com founder, allows car owners to make money by renting their vehicles to other members when they are not being used.

Although the service only launched in Britain in February, the company says subscriber numbers have grown and it plans to expand the scheme to Europe.

26,000
The number of deaths on European roads last year

€18.7bn
Amount saved by cutting road deaths between 2011-13

€18.7bn for the reduction in road deaths between 2011 and 2013.

As Europe reduces the numbers of people harmed on its roads, it must deal with evolving challenges. For example, London, which is seen as setting an example, has seen an increase in the proportion of cyclists and pedestrians hurt even as the number of its motorists who die in crashes falls.

"You need to go into a higher level of detail," says Ben Plowden, director of surface strategy and planning at Transport for London. Police records of accidents are scrutinised and overlaid with data from other sources, to get a more sophisticated understanding of what caused an incident and how to tackle it.

London has a stiffer target than the EU standard: its mayor has ruled that as well as cutting deaths, the number of people seriously injured must also be reduced. The transport department at the European Commission is expected to do as London has done, and add a target for reducing serious injuries by 2020.

Further ahead, the ambition is that almost nobody will be killed or seriously injured on Europe's roads.

The Future of the Car

Heads up on latest in augmented reality displays

Technology

Windscreens take on a life of their own and could increase people's faith in driverless cars, reports *Chris Bryant*

Cruising on the highway in light traffic, an autonomous vehicle suddenly brakes hard. But the "driver" is not worried that the car may have malfunctioned.

The augmented reality windscreen has marked in red a deer in the distance that has stepped on to the road; the driver returns calmly to his crossroad.

Once the stuff of Hollywood movies, augmented reality windscreens are on the verge of entering production.

Head-up displays (Huds) project information directly into the field of vision, so the driver does not have to look down at the instrument cluster. First used by pilots, these systems have been available in cars for more than a decade, first in more expensive vehicles and then hitting the mass market.

The information seems to float in front of the windscreen in exactly the spot a driver should look. Until now, Huds have tended to show only basic information generated by the vehicle, such as speed and navigation commands. But a new generation is set to fuse this with additional data from the car's cameras, radar and GPS. This is set to draw the driver's attention to possible dangers, road features or points of interest, thereby giving the driver "augmented" visual powers.

With navigation commands overlaid graphically on the road ahead, you might never take a wrong turn again. Think of it as an in-car version of a Google Glass headset.

As well as improving safety and navigation, the industry believes augmented reality Hud systems will support "autonomous" driving - or letting the car itself have more control, leading perhaps ultimately to driverless cars - as Huds could make those in the vehicles feel more comfortable.

Marc Necker, manager of augmented reality at Daimler, says: "There will be some customers who are reluctant to let go [of the wheel]. By showing the customer what the car 'sees', we can increase trust in the system."

Continental, the German parts supplier, is developing an augmented reality Hud system that will be ready for production in 2017.

This year, the Hannover-based company demonstrated a prototype that provides full-colour support for the car's advanced driver assistance systems, including a visual warning that the car is drifting out of its lane.

"In an emergency, you do not want to show information [about the danger] somewhere where the driver has to look for it - it needs to be in the field of view," says Eelco Spoelder, Continental's head of instrumentation.

The Continental Hud offers a larger visual plane than previous systems. Dashboard space has limited the size of displays, as their complex and bulky optics systems must be stored below the windscreen. Obscuring too much of the driver's field of vision is clearly not desirable for safety reasons.

"Every object you place in the driver's field of view is potentially covering up something happening in the road," says Hans Roth, director of technology marketing at the infotainment division of Harman, a supplier.

Jaguar Land Rover is working to make display units smaller and has also been



Danger signs: a BMW simulation of a heads-up screen at work

experimenting with a variety of scenarios for augmented reality. For example, it aims to make the bonnet of its SUVs appear transparent, to enable the driver to "see" the obscured terrain.

"It's about adding value to the driver. If you are off-road and can't see a pothole, you drive into it," says Lee Skrypchuk, who specialises in such systems at Jaguar. "This can help people who don't

have the experience or knowledge to drive in particular conditions."

Augmented visual information is not supplied solely by a Hud. The latest incarnation of the luxury Mercedes-Benz S-Class features a night-vision system in the instrument cluster. The LCD display shows the road ahead and identifies potential dangers such as pedestrians and animals in red.

"Video and head-up technology complement each other. The size of the head-up display is limited, so you have to think what you want to show there," says Mr Necker at Daimler.

Indeed, some of the most promising augmented-reality applications for the car make use of smartphones and tablets, rather than in-car technology.

Metaio, an augmented reality technology company based in Munich, has built a service and maintenance app for Volkswagen's ultra-fuel-efficient XL1. By pointing a tablet's camera at the car, a technician can see an image of the vehicle and its parts, and a virtual representation of the work steps required.

"Augmented reality helps you understand an ever-increasing stream of digitalised information," says Thomas Alt, Metaio chief executive. "This is not a gimmick, but driven by the need to make processes more efficient."

In theory, the era of full vehicle autonomy could allow an augmented reality windscreen to show more information about passing points of interest. But for now, drivers need to focus on driving, so distraction must be kept to a minimum.

"It's going to be some time before the driver can sit back, relax and watch a movie," says Mr Skrypchuk.

Automakers spy hazards as sales face difficult times

Continued from page 1

decade at least. But the pressure means advances in clean technology are assured. Spending on connected or autonomous innovation, however, could suffer.

"You're not going to get a fine from the regulator if you haven't got a connected car by 2020," says Mr Hendrikse. "Carmakers are going to be looking to cut costs wherever they can, but the future positioning of these companies is at stake."

A study last month from Boston Consulting Group painted a bleak picture, as a number of manufacturers staged a retreat in the annual listing of the world's most innovative companies, elbowed out by tech and telecoms groups.

300m
Lines of computer code estimated to be found in a luxury car

\$13.5bn
Sum Volkswagen spent on research and development in 2013

But that was not for lack of trying. According to another report, from the Strategy& consultancy, six carmakers ranked among the top-20 research and development spenders globally, and ranked second only to healthcare as an industry. Top of the list was Volkswagen - a company that plans to slash €5bn from its annual outlay at its core VW brand by 2017 and which spent \$13.5bn on research and development last year.

Clearly, carmakers know the importance of evolution. "You need to innovate to stay alive," says Colin Lawther, senior vice-president in Europe for Nissan. "You create a new technology and two years later everybody has it. Then you have to innovate again to drive the brand forward."

The power train, the beating heart of the vehicle, is at the heart of change in

the industry. Electric cars such as the BMW i3 and the Nissan Leaf offer practical, if still pricey, alternatives to the internal combustion engine.

Hyundai and Toyota are advancing the case for hydrogen fuel-cell technology, with models coming out this year and next.

Autonomous technology is being incorporated into cars at an advancing pace, from the Mercedes-Benz S-Class - Daimler's luxury executive car, which can drive unaided in free-flowing and heavy traffic - to the latest Qashqai, Nissan's popular crossover 4x4, which can see all round itself, brake automatically and spot road signs.

Tesla's latest technology will mean that drivers can summon their vehicle from the garage to pick them up at the door.

Carmakers are scrambling to employ software engineers as they vie to control the systems that will run the car of the future. According to Rogue Wave, a US software group, the average luxury car today has more than 300m lines of code - compared with about 8m in the F35 fighter jet.

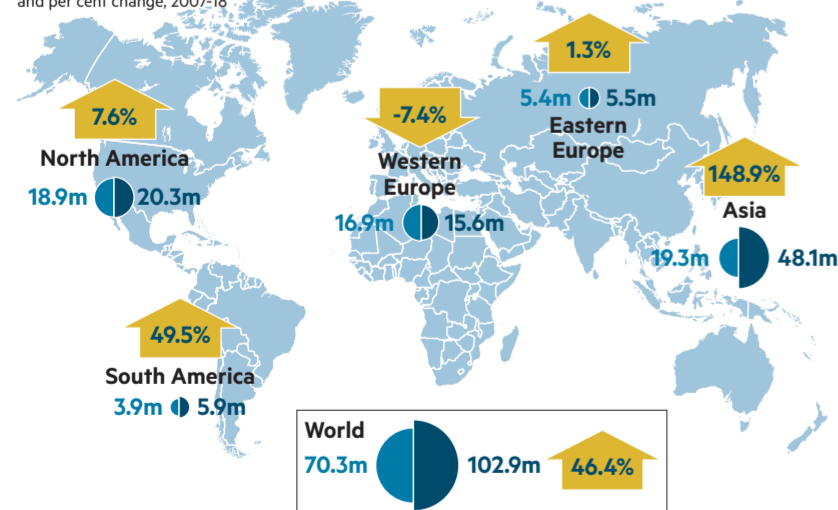
But innovation comes with risks. By the end of July, carmakers had already broken the previous annual record for recalls, highlighting how regulators, and manufacturers, are ever more sensitive to safety issues. The number of patents filed for airbags and seat belts alone jumped almost 40 per cent in 2013, according to Reuters research.

Furthermore, high-tech car innovation must be accompanied by advances in safety, say experts, to avoid the scenario of a vehicle being hijacked by a cyber attacker.

"A successful hacking attack while someone is driving a car? This would... be a show-stopper," says Rainer Mehl, head of automotive at NTT Data, the IT services group. "It has the potential to halt innovation."

Global car sales forecasts

Sales forecasts by major region and per cent change, 2007-18



Source: LMC Automotive

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The Future of the Car

Cost of electric vehicles outweighs their 'green' credentials

Customer resistance

Manufacturers need to flag up environmental benefits, reports *Tanya Powley*

In the world of cars, green typically means "go". But that does not apply to supposedly environment-friendly electric vehicles, which have failed to take off as many had hoped.

Electric cars are considered by many in the industry as the most likely replacement for internal combustion engine vehicles but drivers have given them a lukewarm reception. In most cases, they make up less than 1 per cent of sales in developed car markets.

"The demands and preferences of the drivers clearly highlight the dilemma faced by manufacturers," says Phil

Harrod, partner in the automotive practice at PwC.

He says carmakers need to change the primary concern in buyers' minds from cost to conservation.

Nissan has been the most successful to date by appealing to early green car adopters with its Leaf.

Caely Beecham, an analyst at LMC Automotive, says: "While generally missing sales targets, it has been, without doubt, the most successful battery electric vehicle so far."

According to LMC, there were more than 46,800 sales of the Nissan Leaf in 2013, compared with 22,100 sales of Tesla's Model S vehicle, the second most popular electric car.

Ms Beecham says that, like Toyota's Prius, Nissan's Leaf makes a statement by having a unique look, offering good performance and being well built. However, despite being the world's

most popular electric car, sales have failed to meet expectations.

Renault-Nissan's chief executive Carlos Ghosn said last year that sales were at least four years behind targets which he blamed on the slow rollout of support infrastructure. Poor sales also prompted Renault-Nissan to delay its next electric vehicle - an all-electric version of the Renault Twingo.

Xavier Mosquet, senior partner in the automotive practice at Boston Consulting Group, says consumers who are more likely to buy electric vehicles are typically buyers of expensive cars.

He says this explains the good positioning and success of Tesla. "Its price allows for enough battery capacity to give it sufficient range. It is also a well-designed car, with seven seats and a great consumer interface. Probably the best choice if you want to feel different," he adds.

While most electric vehicles can only drive under 100 miles on a charge, Tesla's Model S has a top range of about 260-300 miles and can charge 80 per cent of the battery in 40 minutes.

Car analysts also point to sales of BMW's i3 electric vehicle, which was launched in the US in April. LMC

46,800

The number of Nissan Leaf cars sold in 2013

Under 1%

Market share of electric vehicles in developed countries

Automotive says it sold more 9,600 vehicles in 2014, up from 505 last year.

"BMW has been radical in the design of the i3 and this has resulted in better performance and range than the typical battery electric vehicle, Tesla excepted," says Ms Beecham.

Car experts say cost has been one of the main factors holding back sales.

"It is more difficult for mass-market brands to succeed in this field, because of the high cost of the electric vehicle battery. This inevitably makes the car expensive compared with conventional rivals," says Ms Beecham.

She believes the efficiency benefits of such vehicles are often outweighed by the cost. For example, a Nissan Leaf in the UK costs about £25,000 before government incentives, while a petrol-driven Ford Focus with EcoBoost technology starts from about £18,295, according to LMC Automotive.

Range limitation and recharging problems also play a role. David Raistrick, head of UK automotive at Deloitte, says electric vehicles have become popular in places such as California because most people live in suburbs and have their own drive way,

so they can park securely and charge overnight. He says: "The majority of European cities don't work in the same way. Roads aren't equipped with the space or the infrastructure to install rows of charging points."

Many in the industry believe carmakers are shifting their focus away from electric vehicles to plug-in hybrids (see story, below left). LMC Automotive's forecast assumes plug-in hybrids will outsell electric vehicles, as fewer compromises, particularly concerning range, are required.

However, Mr Raistrick says there is no consensus on what will power the cars of the future. "Hybrid technology, diesel, highly efficient small petrol engines and hydrogen cells are all being developed as a way of achieving lower emissions and meeting the increasingly strict regulations [being] imposed."

China chooses German partner to build mobile driving network

Car connectivity Plan to develop operating system could generate big profits, writes *Tom Mitchell*

A little-noticed agreement, signed on the sidelines of October's Sino-German "joint cabinet" summit could help determine the shape of internet connectivity and autonomous driving - where vehicles do some of the thinking - in the world's largest car market.

Deutsche Telekom, which agreed to build a car network with state-owned China Mobile, also hopes the deal will open a backdoor on to a previously closed market, illustrating the potential opportunities stemming from advances in connected cars.

The two companies will marry China Mobile's nationwide 4G network to an operating system Deutsche Telekom currently uses for 2m German vehicles. China Mobile, the world's largest cellular company, will have built the world's

biggest 4G network, with 500,000 base stations and 50m subscribers, by the end of this year.

Liu Xin, head of China Mobile's data division, says Deutsche Telekom's technology has been tested in the field, while his company is "confident that sometime early next year we're going to reach 1m [4G base stations]".

Internet connectivity in cars is becoming more common globally. Deutsche Telekom and China Mobile hope their 50-50 joint venture will become a platform, like Apple's iOS or Google's Android operating systems, which third-party application developers can build on.

"Based on our infrastructure you can build entertainment, TV, insurance and repair services," says Horst Leonberger, senior vice-president of the German company's T-Systems division, respon-



Gridlock: a mobile network connecting cars in China's busy cities could help ease road congestion in the country - Larry Downing/AP/Getty Images

sible for in-car connectivity. While the system would allow other companies to develop apps, the two partners would hope to take a proportion of any transaction costs made over their network.

They also want cars to talk to other cars through their operating system. Mr Leonberger says that if enough vehicles were "meshed" together Chinese drivers could avoid jams in the country's notoriously congested cities. He reckons that 10 per cent of cars need to join, "because then you can really use algorithms to predict traffic flows".

There are currently about 180m passenger vehicles on China's roads with about 20m being added every year.

"If you are driving a Volkswagen and I am driving a Mercedes, I would like to know when you are braking," Mr Leonberger says. "Either the industry must standardise the exchange of data, which would take a lot of time, or we establish an open system that can. That is the role we would like to establish with this joint venture."

A more distant prize is the ultimate creation of a network that will allow cars to drive themselves, one that is also being pursued by Google.

Competition to build a network that could one day enable cars to drive themselves in the world's largest car market will be intense. "It's a wide-open market," says Mr Liu. "A lot of companies are attracted to the connected car business and all have their own view of how it is going to develop."

"The main competitor is Google," says Mr Leonberger. "That's the real threat - if they can get access to enough cars. If the car manufacturers don't do anything or don't co-operate, then Google will win. They have already the Android platform and the biggest cloud-sourcing community out there."

However, Google faces big obstacles in China. In 2010, the company aban-

doned the country's internet search market after deciding its famous "do no evil" ethos was incompatible with Beijing's censorship regime.

China-based internet users are redirected to Google's Hong Kong search engine, which is routinely blocked by Chinese censors, as are the California company's Gmail services. Both can only be accessed via virtual private network (VPN) tools.

The Chinese authorities would certainly prefer a joint venture involving the country's largest mobile operator to pioneer future car-to-car networks and autonomous driving.

"We have to obey government laws and regulations," says Mr Liu, a US-educated former IBM executive, when he is asked if the joint venture's operating system will offer VPN services so bored teenagers in the back can access YouTube, Facebook, Twitter and other sites routinely blocked by government censors.

"By doing that, I don't think we're going to reduce our ability to compete."

It is no accident that China Mobile has decided to partner with Deutsche Telekom rather than, say, a US company such as AT&T.

Germany is China's closest western partner and both countries share a common disgust with the extensive US surveillance activities unveiled by Edward Snowden, the fugitive former US intelligence contractor.

The joint venture also gives Deutsche Telekom unique entry to a telecoms market - the world's biggest - where foreign investors are effectively barred from offering fixed-line and mobile services, while being limited to 50 per cent stakes in companies providing value-added services.

It was always unlikely that such an opportunity would be extended to a US or UK telecoms operator.

Sleek hybrids are likely to be the future of motoring - at least for now

Opinion

Carmakers need to play on the emotions of potential buyers, says *Rohit Jaggi*

Car buyers do not purchase vehicles as such. A mature advertising machine makes sure they are buying associations with freedom, potency, happiness.

All that may well be illusory - and a gridlocked expressway on a rainy night would certainly reinforce that suspicion. But buyers sold on the idea of the endless highway are not likely to be satisfied with the thought of an electric car that has a range of less than 100 miles, with an enforced downtime of two or three hours to charge up enough for another 100 miles or so.

Which is why the future, for now, resides in hybrids that can be plugged in but can also refuel at gas stations.

Some of the better hybrids are, moreover, changing car owners' perceptions not just about how functional electric cars can be, but also how exciting. A shining example of this is the BMW i8 hybrid supercar.

A most un-supercar-sized three-cylinder, turbocharged 1.5 litre gasoline engine sits at the back, its 231 horsepower driving the rear wheels. A 131hp electric motor drives the front wheels. The electric motor on its own can propel the car at up to 75mph and the batteries alone can take it 23 miles.

However, when the internal combustion engine joins in, the i8 needs to be limited to 155mph, and can deliver a 0-62mph time of 4.4 seconds. The effect is almost seamless power.

The additions to this near-£100,000 plug-in hybrid are also arresting - vertically opening doors add to the supercar looks.

Crucially, the i8 is helping to reverse

Electric propulsion Why two and three wheelers could have a flying start over their larger counterparts

Two-wheel vehicles have run ahead of their four-wheel counterparts in the race to populate segments of the market for electric propulsion.

A tilting three-wheeled Piaggio MP3 scooter was the first plug-in petrol-electric hybrid vehicle on the market, in 2009, on two, three or four wheels.

The Swiss MonoTracer E cabin motorcycle was effortlessly achieving 250km of range at real-world, high motorway speeds two years ago or so.

However, the path has not been smooth - the MP3 hybrid suffered sluggish sales for example - but increasingly competent electric two-wheelers are appearing. Take those being made by US manufacturers Brammo and Zero Motorcycles (which is claiming nearly 300km of urban range for one of its bikes). The UK-made Agility Sietta R is another two-wheeler that impressed me recently.

Even Harley-Davidson is testing opinion among its notoriously change-resistant enthusiasts for a prototype electric motorcycle, the LiveWire.

What seems clear is that the range



Sky's the limit: the PAL-V

and rideability of plug-in electric motorcycles is on an upward trend. Indeed, the fact many two-wheelers are used as commuters or sunny-day toys means the transition to range-limited electric power may not be too great a problem for many riders.

Another favourite of futurists is vehicles that might also fly and projects that could come on to the market within a few years include the US Terrafugia Transition and the Slovakian AeroMobil.

However, a three-wheeler that converts into a gyroplane, for short take-off runs and almost vertical landings, may beat them to market.

The Dutch PAL-V, tilting, enclosed-cabin two-seater may be ready for deliveries in 2016. If that happens, the future will indeed have taken off.

Rohit Jaggi

The perception of cars being emotional accessories is deeply ingrained. But working with that perception, rather than hoping to overturn it, increases the chances of electric vehicles gaining the acceptance they need and, in many cases, deserve.

To see Rohit Jaggi's test drive of the BMW i8 online, go to: ft.com/futurespeed

Power technology

It can take years of testing before automakers are comfortable with new products, says *Kana Inagaki*

It is more than two centuries since the first electric battery was invented, but reductions in production costs have been surprisingly slow to arrive and the race for smaller, safer and more powerful car batteries has produced few winners so far.

An unlikely pair that emerged as top contenders in the rechargeable lithium ion battery market this year: Silicon Valley electric vehicle start-up Tesla Motors and Japanese electronics conglomerate Panasonic.

Tesla, co-founded by billionaire entrepreneur Elon Musk, has defied convention with the success of its sporty Model S electric car, which claims to be able to travel three times further on a single charge than other electric vehicles that average less than 100 miles per charge. Despite a \$70,000 price tag, Tesla has sold nearly 25,000 Model S units since 2012 and expects to sell another 33,000 this year.

Its success also stems from using Panasonic's laptop batteries and combining these with its own technology for cooling battery heat and linking power cells to deliver faster charging and bigger storage. The vehicle floor is packed with thousands of Panasonic's cylindrical 18650 lithium-ion cells.

Using a readily available commercial technology with an established record is a low-risk strategy for Tesla, say analysts, and the batteries have a cost advantage, as they can be mass produced in existing factories.

Thanks to its deal with Tesla, Pana-

sonic's share of the battery market for plug-in hybrids and pure electric vehicles stood at 36 per cent in the third quarter, followed by Automotive Energy Supply Corporation - a joint venture between Nissan and NEC, an IT corporation, both of Japan - with 28 per cent, according to Lux Research. Panasonic's share was only 3.5 per cent at the end of 2011, when AESC held a 47 per cent share following the launch of the Nissan Leaf in late 2010.

"The winner right now is probably Panasonic," says Lux Research analyst Cosmin Laslau. "What sets it apart is really good technology - and it picked the right partner."

Better known for televisions, Panasonic's links with the auto industry date back to the 1950s. In the hybrid sector, where nickel-metal hydride batteries had been common, the Japanese manufacturer supplied batteries to Ford, Honda, Volkswagen and Peugeot. It also supplies box-shaped, prismatic lithium ion batteries for Toyota's plug-in hybrids and Audi's Q5.

Historical links and a strong record in consumer electronics have benefited Asian manufacturers in a conservative industry that usually takes more than a

The Ryden dual carbon battery uses carbon materials made of organic cotton



decade of testing to become comfortable with a new battery technology.

The market has been brutal to start-ups without the capital to survive the slow adoption of electric vehicles; batteries make up nearly three-quarters of the vehicle price. In the past two years alone, US battery makers A123 Systems and Ener1 as well as electric-car venture Better Place have filed for bankruptcy.

With its \$5bn battery plant in Nevada, Tesla will work with Panasonic to bring down the costs of battery packs by 30 per cent, which will be needed to hit the price target of \$35,000 it has set for its third-generation vehicle that will have a range of at least 200 miles.

Still, analysts warn Panasonic's lead could easily be shaken. LG Chem of South Korea, which supplies battery cells for General Motors' Chevrolet Volt plug-in hybrid, is working on a 200-mile range battery for an electric vehicle with a price tag of \$30,000-\$35,000.

Next-generation battery technologies - from lithium air to dual carbon - are also on the horizon after 2020, which could vastly change the competitive landscape.

A Tokyo-based start-up, Power Japan Plus, has developed a battery that claims to charge 20 times faster than lithium ion batteries. Dubbed the Ryden dual carbon battery, it uses carbon materials made from naturally grown organic cotton. Since the battery does not contain rare earth or heavy metals such as nickel, it promises lower costs and durability. As the temperature is stable during operation, there is a reduced risk of the battery catching fire or exploding. However, analysts say it will take years for carmakers to have confidence in the new technology.

Other promising technologies include lithium sulphur battery cells being developed by UK firm Oxis Energy. French billionaire Vincent Bolloré is promoting an all-solid-state lithium metal polymer battery, deemed safer than lithium-ion batteries. Renault will begin producing Mr Bolloré's Bluecar electric vehicle in 2015.

"Once these technologies are [commercially available], the market will start opening up and that's when we'll see who the real winner will be," says Vishal Sapru, research manager at consultancy Frost & Sullivan.