

The Future of the Car

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Innovators face fight to win hearts and minds

While many of the latest technologies are ready to go, legislation and public acceptance are slower to get started, reports *Henry Foy*

When the most sought-after \$1m supercars are hybrids, when hatchbacks are being made from carbon fibre and when manufacturers are promising volume vehicles that can drive themselves, it is clear the world's car factories and showrooms are geared up for change. Driven by regulations and shifting customer demands, carmakers are pushing the boundaries of how we drive, fuel and interact with cars. Tomorrow's vehicles will be less polluting, lighter and safer. They will be more intelligent and better connected – less of a petrolhead's toy and more of an extension of the office or living room. When this summer BMW launched its i3 model – an electric car made from carbon fibre in a factory pow-

ered by wind turbines – Ian Robertson, the carmaker's head of sales and marketing, said the vehicle's technologies "have the potential to push the industry further forward in the next five years than it has in the past 100". Trailblazers who have taken gambles on future technology have seen their efforts pay off. Toyota's Prius brand is a household name, while US company Tesla's success with luxury electric cars continues to turn heads. Innovators such as Continental, Daimler, Nissan – and outsider Google – have shown that self-driving cars are not science fiction. However, the road to a greener, safer and more advanced future is by no means guaranteed to be a smooth or well-signposted run. In research-intensive areas such as



Ahead of the game: the BMW i3 electric vehicle, made from carbon fibre, is unveiled in London

Reuters

alternative engines, carmakers understand the need to change but are far from united about how. Cheerleaders for certain fuels are anxiously checking their mirrors to see if others are following, while late adopters fret that they have missed the bus. Big breakthroughs that many foresee years ago have failed to materialise. Batteries are still too heavy and too unreliable, while the very public demises of Better Place, which

pioneered switchable batteries for electric vehicles, and Fisker Automotive, a Californian company that produced electric cars, underlined the gulf between plausible and viable. Legislation and public acceptance pose the biggest roadblocks. Many technologies such as driverless vehicles or car-to-car communications are almost road-ready, but introducing those innovations could take years as lawyers pore over the implications and customers remain wary. Xavier Mosquet, managing director at Boston Consulting Group (BCG), says: "Safety, comfort, connectivity and fuel efficiency are the three things that drive the future for carmakers. But all these things cost a fortune." Nevertheless, progress is essential. With sales growth in the US, Europe and other mature markets

expected to remain subdued in the longer term, carmakers are under ever greater pressure to deliver more advanced offerings with each new model to keep customers returning to showrooms. Trends such as a sustained rationalisation of the number of platforms – the frameworks upon which car models are built – and increased sharing of models between brand alliances to cut development costs – mean that companies have to introduce fresh features to stay ahead of rivals. Philip Watkins, director of automotive research at Citigroup, says: "It's going to be all about differentiating yourself, giving yourself a better product, meeting consumer demands." Hybrid, pure-electric and hydrogen-

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Vehicles will be less of a petrolhead's toy and more of an extension of the office or living room

Shortage of electric points puts the brake on sales

Infrastructure

Rollout of national charging networks remains slow, writes *Adam Palin*

The uphill task facing developers of electric vehicle (EV) infrastructure could not be better exemplified than by the financial failure of one of the industry's trailblazers this year. Better Place promised to revolutionise the car industry with its "battery swap" model, where users replace depleted batteries with fully charged ones at designated switching stations. Despite early support from Renault, the French carmaker, and more than \$850m of investment from the likes of HSBC and Israel Corp, the company never gained enough momentum. Following its 2007 launch its sales only crept over 1,000 cars shortly before the company filed for bankruptcy in May. Dan Cohen, the former chief executive, concedes the main stumbling block was that only Renault had stepped forward as a partner. Just one vehicle – the Fluence saloon – was therefore compatible with the company's networks in Denmark and Israel. "Other manufacturers did not follow as we had expected," says Mr Cohen. As well as banking on swift consumer uptake of EVs, Better Place gambled on new technology. Mr Cohen believes battery swapping overcomes the greatest problems that hold back sales: convenience, battery life and recharging cycles, and "range anxiety" – drivers' fear of running out of battery mid-journey. However, EV battery swapping remains peripheral to the prevailing combination of domestic and public charging. "Conceptually, the model works and you will see it adopted in time," Mr Cohen says. With most EVs restricted to low mileage, the development of charging infrastruc-

ture has focused on cities, where the majority of journeys take place. "For the current generation of [short-range] electric cars, most charging will continue to take place at home," says Olivier Paturet, manager of Nissan Europe's zero-emissions unit. The Nissan Leaf, a compact EV, can be charged fully through a domestic socket within four hours. Growing numbers of public EV charging points are being installed by companies such as Chargemaster, which has some 1,000 points at UK supermarkets and car parks. In July, the company announced a partnership with BMW to establish a national charging network for BMW owners, to accompany the launch of the German carmaker's i3 EV. "People want to charge where they are," says David Martell, Chargemaster's chief executive. He says the concept of petrol stations is "redundant" to EV charging. "After all, you don't charge your mobile phone battery in a mobile phone store."

Many believe, however that a network of public fast-charging points is required for the infrastructure to keep pace with ever-improving batteries that allow vehicles to travel further. "Charging from wall plugs is not going to meet the market's needs [in the long run]," says Hans Strengh, head of EV charging infrastructure at ABB, the Swiss-Swedish engineering group. With increased battery range, the limits of home charging will enhance the role of higher-power public charging, he says. Today's fast chargers can fully recharge EVs within half an hour. The location of chargers is "all-important", says Michiel Langezaal, chief executive of Fastned, which is building more than 200 recharging systems in the Netherlands by 2015. Unlike in Estonia, the first country that completed a nationwide EV charging network, the Dutch government has not directly subsidised the rollout of this infrastructure. Instead, it has relied on regulatory

measures to support the companies involved. Many carmakers are supporting the construction of fast-charging infrastructure. In the UK, Nissan is financially assisting Ecotricity, a renewable energy company, as it installs a national network of fast chargers at motorway service stations. Four leading Japanese carmakers – Honda, Mitsubishi, Nissan and Toyota – are collaborating to develop infrastructure in their home market. Tesla Motors, the pioneering electric carmaker, has already built part of a dedicated network of "superchargers" for Tesla drivers in the US. The company decided to develop its own hardware to allow faster charging, and has chosen locations along main routes to enable intercity journeys. Of 100 stations scheduled to be completed by the end of the year, 20 are in use. Tesla has also promised a national network of superchargers in the UK by the end of next year, while French group Bolloré is bidding for a tender to build car chargers in London, after successfully rolling out a network in Paris. JB Straubel, Tesla's chief technical officer, says: "While I don't think [highway] charging will replace the convenience of home charging for drivers' daily needs, it will take away the fear of long drives." Technological advances have led to testing of wireless charging. By allowing drivers simply to park their vehicle in a charging bay for as long as necessary, wireless charging will offer greater convenience, says Joe Barrett, a director at electronics company Qualcomm, which is conducting wireless trials in London. Despite Mr Barrett's claim that "the plug-in option will eventually fade away," caution prevails on wireless charging's potential to usurp existing technology. "I strongly doubt [wireless charging] will cause a great strategic shift in the EV infrastructure sector," says Mr Straubel.

Refuelling Tech running on empty

With hydrogen cell vehicles still largely confined to demonstrations, refuelling infrastructure remains nascent. One of the greatest concentrations of hydrogen refuelling stations is in California, where the number of public stations is set to rise from nine to 20 by the end of this year, according to Keith Malone of the California Fuel Cell Partnership, which promotes hydrogen vehicles in the state. Analysis by CFCEP indicates, however, that 100 stations are needed to sustain a viable market in the state. "Development of the fuelling network... is the paramount issue for the launch of the commercial market for fuel cell vehicles," he says. Current demand

struggles to sustain the infrastructure that has been installed. In Norway, where a 360-mile hydrogen highway was completed in 2009, Statoil later announced its intention to close some of the refuelling stations. Long-term investment will be required ahead of 2015, when the likes of Hyundai and Toyota have scheduled commercial production of hydrogen cell models.

Adam Palin



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Spreading their wings

Flying cars are nearing take off, says Rohit Jaggi

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The Future of the Car

Removal of the human element is key to safety

Crash technology R&D now aims to avoid accidents completely, says Henry Foy

On a test track near Gothenburg, Sweden, a 10-foot tall model moose causes Volvos racing around the tarmac to slow down.

The moose is not dressed as a traffic warden, the cars are just programmed to avoid it. It is part of an industry-wide effort to make driving safer.

Object detection, automatic braking and assisted steering are changing the relationship between cars and drivers, and shifting the way vehicles interact with other road users and their surroundings. "Safety is the price of

admission to this industry," says Toscan Bennett, vice-president of Volvo Cars.

Moose are no joke in Sweden. They cause about 5,000 car crashes a year. But that is just a fraction of the 1.3m deaths every year in car accidents around the world – 3,500 a day.

In response, "active safety", an approach that aims to avert accidents rather than make them less damaging, is one of the fastest-developing technologies as manufacturers fit cars with cameras, sensors and communication systems that enable them



Obstacle course: Volvo is developing object detection technology

to see crashes coming and call for help.

"We've moved from a world of surviving accidents to one where we avoid accidents completely," says Mr Bennett.

"Our goal is that cars do not crash. And one of the ways to prevent cars from crashing is to take the human out of the equation."

Despite the global death toll, cars have never been safer. The percentage of new cars achieving top marks from Euro NCAP, an independent safety and testing organisation, rose from

less than 5 per cent in 2001 to almost 80 per cent in 2008.

Much of this improvement is down to safety features, which have come a long way since Volvo invented the three-point seatbelt in 1959. Typically, groundbreaking safety features appear first in luxury cars or as expensive add-ons, are then leapt on by regulators and are eventually made compulsory for mass-market models.

Airbags, electronic steering control and assisted braking systems – which reduce skidding when turning or

braking – were once unheard of in family cars.

Now it is hard to find a new car in Europe without them. And today car-makers in every price segment are developing radar, infra-red and imaging technology to alert drivers to hazards or automatically engage steering or braking control.

Volkswagen's entry-level Up! model can be fitted with a City Emergency Braking system, which uses a laser to detect hazards, makes braking more sensitive at low speeds and can automatically engage the brakes if it thinks a collision is imminent.

Safety systems have growth potential in developing and fast-growing markets such as India, China and Brazil, where many crash-test regulations and other safety standards lag behind European or North American regulations.

Road safety advances are not just about making vehicles more reactive and robust. Communication systems that allow cars to interact both with road infrastructure and other vehicles are being tested in real-world situations by vehicle manufacturers and IT companies.

Audi, BMW, Daimler, General Motors, Honda and Ford are some of the manufacturers developing car-to-car communication systems that would allow a vehicle that had just driven through a patch of oil or avoided an obstruction to inform drivers behind them of the hazard.

Richard Cornish, global machine-to-machine strategy and industry development manager at Vodafone, says: "This information can be sent to other communications hubs to allow them

to take appropriate action, whether calling the emergency services or adjusting road traffic information such as speed limits."

By 2015, all new cars sold in the EU will feature an eCall automatic distress signaller to alert emergency services in the event of an accident, a feature the European Commission says will save up to 2,500 lives a year.

Drue Freeman, senior vice-president at semiconductor company NXP, says this ability to connect to the outside world could lead to improvements in road safety and better traffic flow.

Meanwhile, at the track near Gothenburg with its moose, other Volvos are stopping without driver intervention at the sight of a

Some Volvos use infra-red cameras to detect obstacles in pitch darkness

child on a skateboard while others use infra-red to detect obstacles even in darkness.

The carmaker is also testing a system that automatically steers the car if it feels the wheels are getting too close to the edge of the road.

That and the obstacle detection systems will be rolled out on the XC90 next year. It is all part of the goal of nobody being seriously injured or killed in a new Volvo by 2020.

"That's quite a bold ambition," says Mr Bennett. "It's something no other carmaker aspires to."



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6:57, the time the Porsche 918 Spyder took to set a new world record*. To take the Nürburgring crown by 14 seconds was surprising. To do so with a plug-in hybrid is revolutionary. It is a performance milestone and a perfect expression of our founding principle. The principle of Intelligent Performance.

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Estimated fuel economy figures for the Porsche 918 Spyder in mpg (l/100km): Urban N/A (N/A), Extra Urban N/A (N/A), Combined 85.6 (3.3). CO₂ emissions: 79 g/km.

The mpg and CO₂ figures quoted are sourced from internal test results using pre-production vehicles, are provided for comparability purposes and may not reflect your actual driving experience. Fuel economy figures obtained in combined hybrid power train mode using a battery charged from mains electricity. *Fastest ever lap of the Nürburgring Nordschleife for a car with global road homologation, set 04 September 2013. 20.6 km lap covered at an average speed of over 111 mph by Porsche factory driver Marc Lieb.

Innovators face fight to win hearts and minds

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powered cars are driving on the world's roads today but progress in finding a definitive replacement for the venerable internal combustion engine will probably continue to be elusive.

Acceptance of greener powertrains – the mechanisms that transmit the drive from the engine to the axle – is slowly revving up, led by the Prius, Nissan Leaf and others. Even ultra-luxury sports cars such as the McLaren P1 or the LaFerrari boast hybrid powertrains, though transferring that technology to volume cars will be crucial.

Pure electric and hybrid vehicles are expected to account for a mere 4 per cent of global sales in 2020, according to LMC Automotive, which tracks and analyses industry trends. Tellingly, BMW designed its i3 to include a petrol engine as a back-up to the electric motor and battery.

"While consumers might say that they care about emission levels, they still care less about that than the price of the car," adds Mr Watkins.

Spluttering progress in alternative fuels and uptake of hybrid, fuel-cell and pure electric engines mean the almost 130-year reign of spark plugs and pistons is in little danger of being overturned immediately.

Batteries, on which plug-in hybrids, pure electric cars and fuel-cell technologies rely, need to be lighter and cheaper. Stefano Aversa, managing director of AlixPartners, says: "I still don't see the conditions for a big surge in alternative engines – the behaviour of consumers has been

incredibly rational."

"The best way to reduce the weight and the emissions is to build smaller cars with smaller engines," says Mr Mosquet at BCG. "The evolution of the standard gasoline engine is definitely going to be the main driver of fuel efficiency for the next 10 to 15 years."

With ever more stringent curbs on carbon dioxide emissions being set by governments, carmakers need to develop smaller, more efficient combustion engines to go into smaller, lighter vehicles.

In a nod to the future, Ford's European version of its EcoSport SUV weighs just 1,300kg and is powered by a one litre, three-cylinder EcoBoost engine.

Advances in autonomous technology look unstoppable, and the race to lead the pack in self-driving is well under way.

"We're in a fascinating time," says Mike Woodward at Deloitte. "When the most important things cease to be performance and become how well it actually takes you from A to B, the characteristics we will look for in a car will change."

Cars that stop themselves to avoid potential collisions are already on the roads. Even executives at rival companies call Volkswagen's Up! "uncrashable" at low speeds, while Nissan has promised to sell the first car that needs no human hand on the wheel by 2020.

Meanwhile, cars that can sense obstructions and brake faster than humans can react are slowly entering the mainstream, in turn throwing up questions for both manufacturers and customers.



Fast track: the Nissan Leaf self-drive is put to the test

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The Future of the Car

Aluminium leads the race for greater efficiency

Bodywork Formula 1 technology has been harnessed to reduce weight, says *Henry Foy*

In 1948, Land Rover built its first Defender vehicle with a body made not from steel, which was scarce and expensive after the second world war, but of aluminium. Sixty-five years later, Jaguar Land Rover's cutting-edge new Range Rover model is built from the same metal, but for different reasons.

"Lightweighting" is one of the car industry's most important areas of innovation, as manufacturers fight to make vehicles more efficient and less polluting, and aluminium is about 40 per cent lighter than conventional steel. As some engineering teams vie to squeeze more output from smaller engines, others are working to make vehicle parts lighter. The spur is provided by government regulations requiring cars to use less energy.

"Lightweighting is critical to ensuring fuel efficiency," says Anil Valsan, lead automotive analyst at EY, the professional services firm.

Carmakers will spend an average of

\$500 a vehicle to reduce weight over the next few years, according to Xavier Mosquet, managing director at Boston Consulting Group.

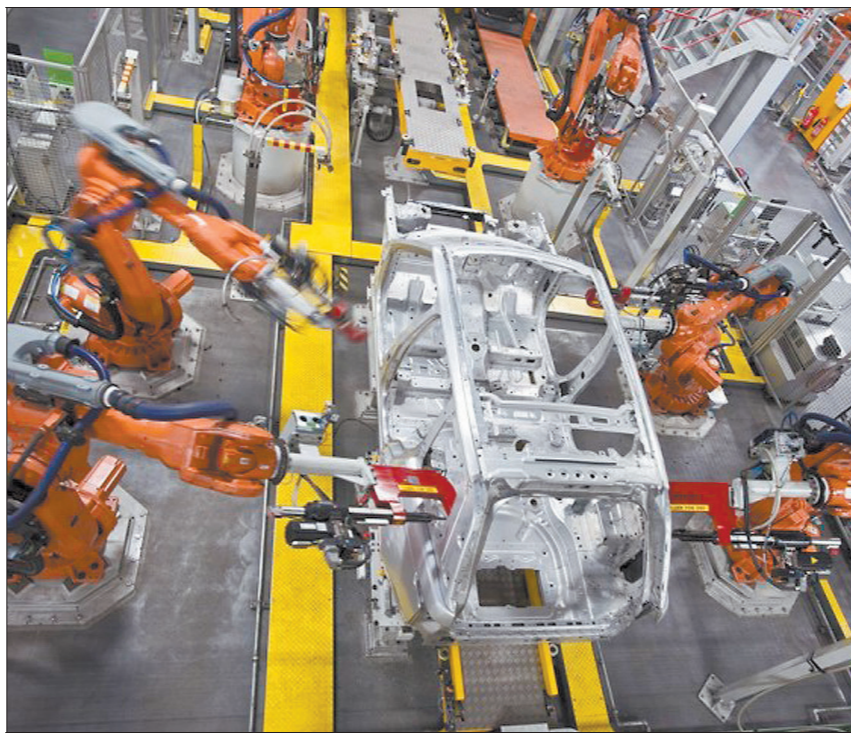
Jaguar Land Rover (JLR) runs the world's largest aluminium body shop in Solihull in the UK's West Midlands. It manufactures the Range Rover and Range Rover Sport from the metal, reducing each vehicle's weight by some 500kg – or roughly 20 per cent.

Consumer demand for more space, added features and improved safety has meant that average car weights have increased by about a quarter over the 30 years to 2006, according to research from Accenture.

Now, strict government targets are forcing carmakers to reduce carbon dioxide emissions drastically. While engine technology is helping, lighter vehicles can also boost efficiency. Compared with the Range Rover's steel-built predecessor, the new model uses 22 per cent less fuel.

It is not just about getting the overall weight down. JLR's aluminium Range Rovers, each held together by 3,722 rivets, require no welding, thereby reducing energy use and cooling requirements at the factory.

JLR, which will use aluminium across its forthcoming Jaguar family of entry-level luxury cars, is not the only manufacturer using the metal; Audi and Aston Martin are also look-



ing to exploit its advantages.

Hybrid structures incorporating both aluminium and steel parts have been used in mass-market cars for about 20 years. Now many see Ford's new version of its F-150 pick-up truck,

Light touch: transition from steel-based manufacturing to other materials 'will not be without its headaches'

which is expected to rely heavily on aluminium for its body panels when released next year, as the metal's big breakthrough.

But the higher cost of producing aluminium means that it is not always suitable for the cheaper end of the volume market, and shifting materials and changing production techniques are not simple.

Melissa Stark, global managing director for new energy at Accenture, says: "Lightweighting the car industry will not be without its headaches. Transition from steel-based manufacturing to other materials requires a radical shift in supply chains for carmakers, and will probably be resisted by metals suppliers."

Indeed, steel, long the unrivalled metal of carmaking, is fighting back. High-strength steel varieties exist that use less metal to achieve the same rigidity and strength, and they are cheaper than aluminium and more compatible with existing production lines. They are already being used by mass-market brands such as Volkswagen and Hyundai.

Hyundai, the only car manufacturer with its own fully integrated steel mill, has tasked 300 metallurgists with producing a lighter, stronger and longer-lasting metal.

The South Korean company uses high-tensile variants for 50 per cent of

the steel in its cars, reducing average vehicle weight by about 10 per cent. Mr Mosquet at BCG says this can produce other advantages: "If you have better steel that is more resistant, you can keep the same rigidity with less material. So you gain in terms of weight and cost with a better design."

For the world's most luxurious and high-performance cars, neither aluminium nor advanced steel are good enough. McLaren Automotive, the UK sports car manufacturer, builds its £900,000 P1 model with a carbon fibre interior body using techniques learnt while making Formula 1 cars.

Carbon fibre, with its high strength-to-weight ratio, is making its way into mainstream volume models. BMW's electric i3 model is built using carbon-fibre-reinforced plastic to accommodate the car's chunky battery. This is seen as the material's breakthrough into the mainstream.

Manufacturers are also looking beyond the car body. Engineers are replacing parts such as engine blocks and gearbox components with aluminium alternatives, and finding ways to reduce the weight of internal fittings.

JLR is even aiming to shave kilograms off its in-car entertainment systems, while McLaren has ditched carpets and made its windscreen glass thinner. In the race for efficiency, every little helps.

Low demand puts pressure on the battery

Greener cars

Fuel efficiency means power cells are more important, says *Chris Bryant*

Car batteries used to be an overlooked staple of the automotive industry. So long as the conventional 12-volt, lead-acid battery got the car to start and the lights to work, consumers were not bothered.

But batteries have taken on a new importance, as the industry strives to develop fuel-efficient hybrid and pure-electric cars. Rechargeable lithium-ion batteries are the dominant technology in pure electric vehicles and are gaining ground in the hybrid sector, where nickel-metal hydride batteries have led the way.

The cost of lithium-ion batteries, their size and the range they provide a vehicle with, are limiting factors in the move to full electric mobility.

Pure electric vehicles – such as the premium Tesla Model S, which can travel 300 miles when equipped with a 85kWh battery, and the more cost-efficient Nissan Leaf, which averages 75 miles per charge – have shown the potential of the latest lithium-ion batteries. Passenger sales of electric vehicles are expected to double globally this year compared with 2012.

Electric vehicles have still not seen the level of demand expected, primarily because of higher costs and consumer worries over range. This has put pressure on the battery industry, which needs to build scale to push down costs and fund innovation.

Competition has led to a string of insolvencies, including that of US-based A123 Systems, and several joint ventures set up to spread development costs – including one between South Korea-based Samsung SDI and Germany's Bosch – fell apart after disagreements over strategy. Bosch has since joined with Japan's GS Yuasa International and Mitsubishi to develop next-generation lithium-ion batteries.

Ali Izadi, analyst at Bloomberg New Energy Finance, says the market

for fully electric vehicle batteries is "hotly contested and there is a big supply-demand imbalance".

Panasonic (which supplies Tesla), LG Chem Power and Automotive Energy Supply Corporation – a joint venture between Japan's Nissan Motor Company and NEC Group – together control more than 93 per cent of the market for pure electric vehicle batteries. Prabhakar Patil, chief executive of LG Chem Power, which supplies battery cells for the Chevrolet Volt, says there has been "a lot of hype, particularly around battery electric vehicles" but he insists "the fundamentals are still right and the growth is there".

He notes that, on a dollar-per-kilowatt-hour basis, commercial lithium-ion battery costs have fallen to a small fraction of what they were when the batteries first appeared in 1991. Compared with 2010, prices are expected to drop by half by 2015-16, Mr Patil adds.

A further difficulty is the lack of a standard design. Costs will fall more quickly once suppliers can supply standard batteries.

Costs have encouraged companies to look beyond pure electric vehicles to hybrids and microhybrids, which feature stop-start capability and regenerative braking. They are gaining ground in Europe thanks to emissions rules.

Johnson Controls says its microhybrid solution, which combines a 12V lead-acid battery and a 48V lithium-ion battery, can deliver fuel-efficiency savings of up to 15 per cent over a conventional vehicle.

In contrast to high-cost full electric vehicles, the additional cost for such a hybrid solution will be hundreds, not thousands, of dollars, the company says.

Brian Kessler, head of Power Solutions at Johnson, says: "The capital intensity needed to ramp up to full electrification is being adopted rapidly. By migrating [to hybrid and then full electric]... I think we can get there over time and still be cost-effective."

Companies are working on the next generation of electric vehicle batteries; IBM is developing a battery chemistry called lithium-air. Analysts believe that technology is at least a decade away.



Charge Exempt.

The new Panamera S E-Hybrid is the first plug-in hybrid in the luxury segment. Thanks to CO₂ emissions of just 71 g/km it is also exempt from both road tax and the London congestion charge.

It uses Porsche's E-Hybrid technology to deliver the thrilling driving experience you would expect, alongside a level of efficiency you might not. The figures speak for themselves: 416hp and 0-62mph in 5.5 seconds, yet 91.1 mpg on the combined cycle and up to 21 miles on electric power alone.

The new Panamera S E-Hybrid.

The DNA of the sports car has evolved.



Power up: a Tesla Roadster electric sports car

Bloomberg



PORSCHE

Official fuel economy figures for the Porsche Panamera S E-Hybrid in mpg (l/100km): Urban N/A (N/A), Extra Urban N/A (N/A), Combined 91.1 (3.1). CO₂ emissions: 71 g/km.

The mpg and CO₂ figures quoted are sourced from official EU-regulated test results, are provided for comparability purposes and may not reflect your actual driving experience. Electric range is dependent on driving conditions. Power output, performance and fuel economy figures obtained in combined hybrid power train mode using a battery charged from mains electricity.

The Future of the Car

Young drivers want smarter options

Technology Vehicles need the latest in on-board connectivity and entertainment if youthful buyers are to be attracted back, reports *Camilla Apcar*

Carmakers are battling to meet the demands of their customers as far as in-car entertainment systems are concerned. Requirements are being driven up by the standards people expect of their smartphones.

In addressing the problem, manufacturers hope to meet the needs of a dwindling demographic – young car buyers in the mature markets of the west.

The proportion of buyers under 30 has fallen since 2003. In the US this year, it stands at just 7 per cent of total new car sales, according to a study by research company Strategic Vision.

A number of factors have caused the decline, including unemployment, living in cities and car sharing.

In the UK, buyers under the age of 27 accounted for just 2.6 per cent of Honda's total sales over the past six years.

Carmakers know in-car entertainment technologies are important to younger buyers. "What we're seeing is a very high percentage of people in that demographic looking for integrated services [such as smartphone connectivity] when they buy a car," says Rick Hanna, global automotive leader at PwC, the professional services company.

He adds that drivers aged between 18 and 35 place more emphasis on in-car technology than older people. Such expectations include access to the apps, social media and games available on smartphones.

In-car music no longer relies on a radio or CD player. One development for European drivers has been a direct-to-car music streaming service introduced in BMW's updated 5-Series by Rara.com.

"The more a car can be seamless in how an individual experiences their entertainment, the more successful the vehicle sales will be with the younger generation," says Alexander Edwards, president of Strategic Vision.

Technologies such as MirrorLink, a standard developed by the Car Connectivity Consortium (CCC), eliminates the need to hold a smartphone by duplicating the phone's display on the vehicle's screen.

This has been adopted by PSA Peugeot Citroën and Toyota. A wireless



update coming out next year will allow third-party developers to make their applications compatible.

Alan Ewing, president of the CCC, says such technologies are going to become ubiquitous as smartphone sales increase.

The installation rate for navigation systems in vehicles imported from the US rose from 0.3 per cent in 2002 to 19.6 per cent in 2012, says PwC.

Mr Hanna says in-car entertainment providers can expect a similar surge. The automotive industry, however, is struggling with development cycles of three years or more.

"For the car industry, it's quite difficult to keep up with the mobile phone industry," says Pim van der Jagt, head of research at Ford, which

Cool play: Car Connectivity Consortium's MirrorLink duplicates a smartphone's display

has made its AppLink service, part of its Sync system, open-specification so that smartphone apps can connect to Sync, allowing the driver to control them via voice and Bluetooth.

More than 1m cars in the US are equipped with AppLink and the service will be brought to Europe by the end of this year.

Not all technologies can be used when a car is moving. MirrorLink and some gaming and video-based apps require vehicles to be stationary.

Mr Hanna says such features will be of increasing significance. "I don't think it would drive a decision to buy... but once they've decided to buy a vehicle, it is a differentiator."

Audi has showcased prototypes with 3D displays that can be viewed

from multiple angles. General Motors is exploring how passenger windows could be used as interactive display systems, coupling augmented reality and a tablet-type experience.

Such services require a good internet connection. The Audi S3 Sportback will be the first car in the UK with 4G LTE mobile internet connectivity, which should be fast enough to stream a high-definition film.

Although such systems have yet to affect sales, Pranish Kumar, Microsoft's connected car group programme manager, says advanced capabilities will continue to appeal to "a generation of consumers for whom their smartphone is one of the most personal and important devices in their life".

Four wheels good, two wheels better

Motorcycles

Sales boom in Asia and other emerging markets with income a key factor, writes *James Crabtree*

A short drive from the southern Indian auto hub of Chennai, in the industrial satellite town of Oragadam, is a site that seems to epitomise the division between the world's car and two-wheeler industries.

"India's Detroit" houses large factories for some of the world's most prestigious auto companies, with Oragadam boasting facilities for both Renault-Nissan and Daimler. But the area's newest – and smallest – plant belongs to a less well-known outfit: the British heritage motorcycle brand Royal Enfield, whose popularity has collapsed in the developed world, but which has gone on to find new success in India.

The downfall – and eventual reinvention – of Royal Enfield is characteristic of the industry, which is tiny in the west but growing rapidly in Asia and other developing economies in South America and Africa.

Drivers in western markets prefer cars, using motorcycles mainly for leisure. Customers in emerging markets, most of whom cannot afford four wheels, provide the bulk of sales in a global industry that sold 54m motor bikes, scooters and mopeds last year, according to Datamonitor.

Siddhartha Lal, managing director of Eicher Motors, which took over the moribund Royal Enfield brand in 1994, and gradually turned it around, says: "In the UK there used to be 40 to 50 motorcycle brands, but very few survived the onslaught of Japanese bikes, or when people switched to cars. But in India, we now have a strong base and we've started exporting much more both to emerging and developed markets, building on the success we've found in our domestic market."

Analysts at Credit Suisse say that two-wheeler ownership is driven by two factors: income and weather. Richer and colder countries have especially low rates of adoption. In emerging economies, motorbikes are much more popular than cars.

India has overtaken China to become the world's largest market by volume, selling more than 15m two-wheelers last year, says Credit Suisse, compared with 3m cars.

Some southeast Asian countries have a particularly high penetration, with close to a third of Thais and Malaysians owning some form of motorbike.

Nor do all two-wheeler owners hanker after a car. Santosh Dubey bought a Splendor, a popular mid-range bike from Hero, India's largest manufacturer by sales, a few years ago. But he uses it only when he goes to his family's home: "I keep it in the village," he says. "I don't need it in Mumbai, because we have trains and buses here."

Deepesh Rathore, an auto analyst based in New Delhi, says: "Some manufacturers, including Honda, Hero and Yamaha, are looking at ultra-low-cost bikes, costing about \$600, which could prove very popular in countries such as India."

Viren Popli, executive vice-president at Mahindra & Mahindra, an Indian automaker that recently moved into two-wheelers, says: "A lot of customers in small-town India will have a car, which they use for the weekend or special trips with family, but they will definitely have a two-wheeler for shopping or commuting too."

Production-wise, the industry is dominated by manufacturers from Japan, China and India. Demand for their products has slowed recently in some larger markets, notably China and India.

Two-wheeler sales in other emerging markets tend to be resilient, as their users often have relatively few public transport options.

"In India, you have a large number of children every year who are either leaving school and going to college or starting work, and they need transport," says Mr Popli.

"The same is true if you are a plumber," he says. "If you don't get to your job, you don't get paid. So as people move into the job market, they have no choice."

The two-wheeler industry's growth depends on yet more expansion in other emerging markets. Africa is a notable growth opportunity, with manufacturers including India's Bajaj Auto targeting exports to large underserved markets such as Nigeria and Egypt.

Beyond new markets, the future for two-wheelers involves a move upmarket. Manufacturers used to focus on fuel efficiency and low costs, but many are now emphasising improved safety and comfort.

Add-ons such as improved technology, music systems

"You get more miles out of the same fuel with a bike than a car"

Rajesh Chheda

or extra storage are important, too, with the latter factor appealing in particular to Rajesh Chheda, who owns an Activa, a scooter made by Honda of Japan, the world's largest producer of two-wheelers.

"You can store things on the floor in front of the seat and there is a compartment where I have stored up to Rs200,000 [\$3,222] before," he says. "Also, you get more miles out of the same fuel with a bike than a car."

Makers of two-wheelers are trying to find customers at the lower end of the market, especially women, whose increasing independence and earning power has seen sales of scooters grow faster than motorbikes in south Asia.

Deepesh Rathore, an auto analyst based in New Delhi, says: "Some manufacturers, including Honda, Hero and Yamaha, are looking at ultra-low-cost bikes, costing about \$600, which could prove very popular in countries such as India."

Additional reporting by Avantika Chilkoti.

Work gathers speed on sustainable alternatives

Green developments

Manufacturers form tie-ups to tackle regional differences, reports *Chris Bryant*

The car as we know it is not so much hurtling towards a crossroads as cautiously approaching a big, confusing roundabout.

Carmakers, under pressure from western governments to reduce emissions, need to find alternatives to conventional petrol and diesel engines.

Green technology options abound but progress has been slow and the combustion engine that has for decades been the mainstream option shows no signs of being unthroned.

Electric vehicles – once

seen as the future of the car industry – are expected to account for less than 1 per cent of global car sales in 2020, according to LMC Automotive, an industry analyst. When plug-ins and other electrified hybrids are included, that figure rises to just 4 per cent.

Yet alternative technologies as a group are expected to play an increasing role in the future of cars, which means the leading manufacturers cannot ignore them.

Luxury German carmaker BMW in September joined the ranks of the converted with the unveiling of the i3, its first all-electric model, while Volkswagen, Europe's largest manufacturer by sales, announced it would develop electric cars for the first time this summer.

"I think they have taken a view that they have to be looking at all the major technologies, because they

can't afford to be left behind," says Al Bedwell at LMC Automotive.

The approach taken by Vauxhall is typical of many. The UK manufacturer, which works with Opel is part of the European arm of General Motors of the US, has a three-pronged strategy.

First, it is continuing to refine the combustion engine in terms of emissions and so-called "lightweighting". Second, it is investing in electric vehicle development, seeking a successor to its Vauxhall/Opel Ampera plug-in hybrid – the European cousin of the Chevrolet Volt. Third, it is working on other hybrid options.

This landscape is complicated by regional differences. In Japan, hybrids accounted for 20 per cent of sales last year, partly because of government incentives. There is signifi-

cant demand in the US, but less in Europe, where petrol and diesel power 96 per cent of cars.



Final touch: the BMWi3 factory in Leipzig

"Manufacturers are taking a global view, because the requirements differ considerably by region. What would work in the US or Japan is not

going to work in Europe," says Mr Bedwell.

As a result, carmakers are clubbing together. GM and Honda in July announced a seven-year alliance to build hydrogen fuel-cell vehicles following similar tie-ups announced in January between Toyota and BMW and Daimler, Ford and Nissan.

By "spreading costs and creating economies of scale, we will ultimately bring hydrogen fuel-cell vehicles to market faster and, crucially, at a lower price", says Andy Palmer, executive vice-president at Nissan.

There is much excitement in the industry about this technology.

Some say that by the time the problems facing electric vehicles – range, cost and recharging networks – have been overcome, carmakers will have moved on to

hydrogen-powered vehicles. Others say the lack of vehicles, recharging points and fuel mean hydrogen has little chance of going mainstream soon.

"From a theoretical point of view, I can't see how it is going to happen, unless there is a breakthrough in one of those areas," says Ian O'Gara, head of global biofuels at Accenture, the management consultancy.

But Acal Energy, a UK chemicals company, says it has made a breakthrough in developing a liquid catalyst that slashes hydrogen vehicle costs by reducing the use of expensive platinum, while delivering performance comparable with diesel engines.

It has signed development agreements with six leading carmakers in the US, Germany and Japan and plans to license the technology to the manufacturers.

Environment

Some fear that Renault's Tangiers plant and others are feel-good gimmicks, says *Borzou Daragahi*

In the hills of Morocco's Tingitana peninsula is a car plant that runs on olive seeds, almonds and eucalyptus wood, produces little waste water and nearly no carbon emissions.

Renault's factory south of Tangiers is an experiment in environmentally conscious automobile manufacture. Producing 170,000 cars a year, it is the first – and

so far only – car factory to run on biomass, but it is not the only one to use alternative energy. BMW's Leipzig factory is wind-powered.

"When we think of a green car company, we automatically think of one that makes low-emission cars," says Tobias Reich, an automotive expert at PA Consulting. "But what about the environmental impact of the vehicle production process? Making 'green' products is only part of the journey towards sustainability."

Many worry that the Tangiers plant and similar factories risk being feel-good gimmicks that spruce up the image of an industry that is a big cause of air

pollution and emissions. Experts worry that such production methods could give a false impression.

John Barrett, professor of sustainability research in the environment faculty at the University of Leeds in the UK, says: "I'm pleased if they can reduce emissions in their factory, but my concern is it gives a false impression that the use of a car and the whole supply chain of a car has an extremely low impact."

"The whole upstream supply chain – before it reaches the car factory – is really carbon-intensive, so it's incomplete information if they advertise that they have a low-carbon or zero-carbon factory. It's a very intense carbon product to produce

and it's an intensive product to use. So it's really about how honest this play is, and to me, it's not."

Prof Barrett, who researches sustainable industrial techniques, says the production of steel to make cars, and their use on roads afterwards, produces far more carbon than the actual assembly.

He is worried that Renault and other companies' environmentally friendly plants amount to little more than attempts to relieve consumer guilt. Indeed, Renault cars built in such "green" factories, along with those that produce fewer than 120 grams of carbon per kilometre, or that are made of mostly recyclable materials, come

with prominent eco-friendly labels.

Such criticisms do little to allay Renault's enthusiasm. Branding or not, an environmental ethos is perceptible among the plant's 4,200 employees.

The project was almost scuttled because of the economic crisis in Europe. Morocco, eager for the jobs the plant would create, pitched in with financing and generous tax breaks.

"We signed on to build a big competitive factory in Morocco," says Gaëlle Archaimbault, Renault's chief of environmentally sustainable development. "As the project was being put together, I was asked if I could do something for the environment."

Renault built the power plant for the factory in collaboration with Paris-based Veolia Environment, the waste management and energy company.

The plant's twin 6.5MW generators burn up to 60 tonnes of biomass a day, heating water that drives the machinery. Local suppliers provide much of the organic material.

The factory is hooked into

"Making green products is only part of the journey towards sustainability"

the national electrical grid and can fire up a natural gas generator as a back-up.

So far, biomass costs are about half those of using power from the electricity grid and a quarter of those of natural gas, but prices are rising, says Thierry Geniteau, chief engineer at the power plant.

Also, while the costs of using biomass are a fraction of those of using electricity, Ms Archaimbault says the initial investment was large. At least \$50m of the plant's \$1bn price tag went towards sustainable development technologies, excluding the cost of re-designing a standard plant. The factory recycles everything from waste water to the hot air it produces.

Ms Archaimbault says Renault has learnt that there are certain environmentally friendly steps that must be incorporated into the original design and cannot be added later.

These are such as the system by which highly heated water, under pressure, circulates and powers the machinery.

The plant makes 400 cars a day and the company aims to more than double capacity by 2016.

Despite the green ethos, Ms Archaimbault says the bottom line was never far from anyone's thoughts: "We built this project with investment goals.

"We're not a laboratory. We wanted something that works and is practical."