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An industry charged up

By John Reed

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The vanguard of a green automotive revolution will roll out next spring on an unlikely set of wheels: a Mercedes luxury sedan. The marque's S400 BlueHybrid will be the first mass-produced vehicle equipped with a lithium-ion battery, like the ones in laptops or mobile phones - but powerful enough to help propel a large luxury car.

The S-Class car, a "mild" hybrid that will still draw most of its power from petrol, is unlikely to outsell Toyota's top-selling Prius, nor - though fuel-efficient for its size - will it be the greenest car on the road. But its battery will give it pole position in a potentially paradigm-shifting technology.

Other carmakers are to follow within two to three years, with cars that use lithium-ion to provide most or even all of their power from electricity. The coming large-scale hybridisation and electrification of cars promises to transform how they are made, who profits from them and the way they are sold and driven.

"There's a tremendous momentum and electric vehicles will be introduced very quickly in the next decade," says Wolfgang Bernhart, partner with Roland Berger Strategy Consultants.

If oil prices continue to rise and battery prices fall, he thinks electric vehicles could come to account for more than 25 per cent of the European market and 10 per cent globally. The estimate does not include hybrids, which have combustion engines but are powered partly by batteries that recharge from energy released by the car.

If so, it would mark one of the biggest technological shifts in a century of automotive history. Hybrids today account for a tiny portion of total automotive sales - less than 10 per cent even for Toyota, which is by far the market leader. Pure electric cars are rarer still, seldom sighted outside California.

What can change that - and what can still get in the way? After all, electric cars have had false starts before, failing to win consumers' acceptance because of their cost, performance or driving range. General Motors discontinued its pioneering EV1 in 2003, citing related concerns and, in the words of a recent documentary, "killing the electric car".

Yet surging petrol prices, advances in lithium-ion technology and growing environmental pressure on manufacturers and motorists to adopt greener vehicles are giving electric and hybrid models a new and arguably permanent lease on life. Carmakers are fast-tracking an unprecedented number of electric and hybrid vehicles through their product pipeline. By 2010 GM will be using lithium-ion batteries in three of its Saturn and Chevrolet brand hybrid cars. GM is introducing hybrids at the rate of one per quarter and says it will have 16 by 2012.

GM's signature green vehicle of the moment - executives describe it as a "moon shot" - is the Chevrolet Volt, a plug-in electric car due to launch in late 2010. The car will have enough lithium-ion power to send most American drivers on electric power to work and back home, where they can recharge the car in their garage at night.

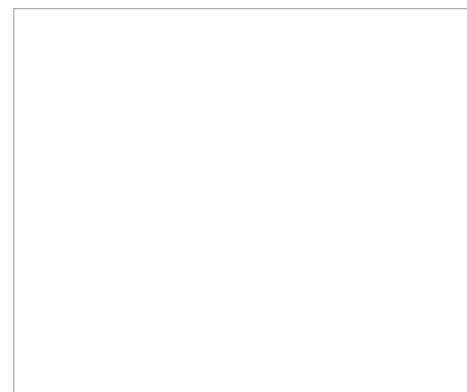
A petrol "range extender" will back up the electric motor on long trips but GM claims most commuters will visit petrol stations only rarely. Toyota also plans to have its plug-in hybrid on the road by 2010 and hybrid versions of all its cars by the 2020s.

Renault/Nissan, the industry's third-largest group, will go further, with pure electric cars providing an expected range of about 100 miles (160 km), to be sold in the US and Japan from 2010 and globally from 2012. Carlos Ghosn, the alliance's chief executive, has identified leadership in electric vehicles as a top objective in Nissan's new five-year business plan.

While as recently as a year ago carmakers' green-car announcements often had overtones of worthy science projects or corporate window-dressing, their actions in recent months point to electric propulsion becoming a core business. "You're going to see more changes in powertrain technology over the next five years than you've seen in the last 50," says Rod Lache, an analyst with Deutsche Bank.

Financial markets are beginning to tally the potential for profits from this technological step-change. AllianceBernstein, the US asset manager, estimates that the market for automotive batteries alone could grow from about \$9bn (£4.5bn, €5.7bn) now to at least \$150bn by 2030. By that time, hybrid and electric cars could make up most of the world's 1bn-plus vehicle fleet. A Morgan Stanley report describes plug-in electric vehicles as having the potential to "revolutionise the automobile as we know it". It compares the nascent industry to producers of MP3 players in 1998.

As the car industry goes electric, new companies will enter the picture. Battery manufacturers are vying to develop products and build factories capable of scaling up to meet bigger demand. Power utilities are forging bonds with carmakers, seeing electric vehicles as a significant future source of demand for their off-peak capacity. Other companies are studying ways of building the infrastructure to recharge and service electric cars. Toyota and EDF, the French utility, are working together on recharging spots around Europe. Project Better Place, a \$200m US start-up, is working with Renault/Nissan on recharging venues to back the roll-out of electric



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cars in Israel and Denmark and aims to expand its business to the UK and elsewhere.

If the technology lives up to its promise, it will diminish cars' environmental impact as countries such as China and India adopt mass "motorisation". China's government is studying ways of promoting electric technology with an eye to leapfrogging its industry's overseas competitors. Emerging automakers including Chery, BYD and Geely are developing or adopting it in cars. "We have to be ready if they decide to incentivise hybrids," says Nick Reilly, head of Asia-Pacific for GM, which last month premiered a hybrid version of its Buick LaCrosse model in Beijing.

Like most revolutions, this one has complex causes. The first is technological: breakthroughs in lithium-ion are now delivering batteries light and compact enough to fit into cars without weighing them down or cramping the cabin but with enough energy to propel them over meaningful distances. While earlier electric cars had prim "eco-car" designs and short ranges, smaller batteries will therefore make for better-looking vehicles with much-improved performance. Tesla Motors and Fisker Automotive, California-based electric car start-ups, are even putting the batteries into sports cars.

Tighter environmental regulations and \$135-a-barrel oil are also focusing carmakers' minds as never before. The European Union is legislating to force manufacturers to cut their average carbon dioxide emissions by about one-quarter by 2012. CO₂-based tax rules in about a dozen European countries are pushing drivers into lower-emission cars, as are congestion-charging schemes in cities around the world. America last year introduced fuel-economy rules requiring carmakers to boost average miles per gallon. California is leading a push by several US states to require carmakers to offer zero-emission vehicles.

Even more important, there are signs that growing production scale and rising carbon taxes are easing the main deterrent to drivers buying hybrid and electric cars: price. The Prius, largely because of its expensive battery, costs as much as \$5,000 more than similar conventional cars. But a study by Edmunds.com, a US car-buying website, concludes that the gap is closing. Takeo Fukui, Honda's president, last week said he saw the price differential between petrol and hybrid coming down to about \$2,000. His company is expanding its range of planned hybrids and hopes to sell 500,000 of them a year by the early 2010s.

In a perhaps more telling sign of changed times, GM - which sells most of its cars in America's heartland - is producing hybrid versions of its bulky core vehicles such as the Chevrolet Tahoe sport utility vehicle and the Silverado pick-up truck, which are particularly vulnerable to rising pump prices.

But GM describes the Volt as its most important vehicle currently under development. The project is being overseen directly by senior managers including Bob Lutz, GM's global head of vehicle development and an acknowledged lover of fast, big-engined cars.

To be sure, the future of carmaking will probably never be entirely electric. Because of the need for recharging points, all-electric cars are likelier to flourish in dense urban centres. Carmakers continue to develop ever cleaner petrol and diesel cars that achieve more miles per gallon by using smaller engines, lighter materials and better design but sacrifice little in performance. Some will contain hybrid powertrains but many - especially smaller cars - will not. Even Mr Ghosn, an early enthusiast of electric cars, acknowledges that they will form only part of a future palette of energy-saving automotive technologies in coming years.

Questions also hang over lithium-ion. The batteries have a tendency to overheat and catch fire in smaller appliances, an event known as "thermal runaway". Carmakers and battery manufacturers say their products will be safe but the risk is nightmarish for automotive groups.

While GM is hurrying to meet its 2010 deadline to launch the Volt, Toyota - which has struggled with quality issues recently - is giving itself the time to study performance and reliability issues drivers will face. Honda, while forging ahead with hybrids, remains sceptical about electric cars and will use current-generation nickel metal hydride batteries in its hybrid next year. "Safety is the critical issue," acknowledges Charles Gassenheimer, chairman of Ener1, a producer of lithium-ion batteries.

Despite these doubts, hybrid and electric cars will be helped by the constraints that are emerging for competing cleaner-car technologies. Cleaner diesel cars have dramatically brought down average emissions in Europe but diesel now accounts for about half of the market and carmakers are looking elsewhere to cut their emissions. Diesel's penetration is expected to increase in the US and China, the world's two largest vehicle markets, but in both countries it faces a battle for acceptance.

Biofuels form part of the automotive industry's response to tighter environmental regulations but a growing debate around their impact on food prices could stunt their potential. Most carmakers reckon hydrogen fuel-cell cars are at least a decade from commercial viability. This leaves electrification as the industry's simplest way to deliver the big increases in miles per gallon and reductions in CO₂ that regulators are demanding.

To build a mass market, manufacturers recognise they will have to develop electric vehicles that ask drivers to sacrifice little or nothing in comfort or convenience. GM, while grappling with designing the Volt around its T-shaped battery pack, speaks of the need to address "range anxiety", drivers' worries of being stuck with nowhere to recharge. The car's range extender is meant to address this.

Project Better Place is proposing an arrangement under which drivers would swap their cars' depleted batteries for recharged ones within five minutes. Shai Agassi, its founder, says drivers could pre-pay for recharging, much as they would for mobile phone air-time, and companies like his might offer cars "for free" as part of a long-term contract. Some carmakers express doubts about the logistics of swapping batteries and other aspects of the company's plans.

For battery producers, the challenge is to develop batteries that are safe and capable of recharging fully, over the decade or so of a car's life, without losing power the way mobile phone batteries have tended to. They are also contending with the need to make large up-front investments in a fast-moving technology. Unit costs will only come down once they build scale.

GM has invited subsidiaries of Germany's Continental and South Korea's LG to compete for the business of supplying batteries for the Volt. But Toyota, Nissan and Mitsubishi, in keeping with Japanese carmakers' traditionally closer relationships with suppliers, have moved to maintain control through stakes in lithium-ion joint ventures.

Independent companies such as Johnson Controls, Ener1 and A123 Systems - working with Continental for the Volt - are entering the field to produce cells or fully integrated battery packs. "It's an alphabet soup," says Alex Molinaroli, head of power solutions at Johnson Controls. "Clearly there are going to be winners and losers."

The perils of the coal-fired coupé

Electric vehicles offer the best chance of creating zero-emission cars - transport that has no adverse impact on the climate. The potential prize is huge. According to the Stern report, a 2006 study commissioned by the UK government, transport is the world's third biggest source of greenhouse gas emissions, accounting for 14 per cent of the total. The number of vehicles in use around the world, moreover, is expected to grow rapidly as emerging economies develop.

But several conditions need to be met before the technology can be classed as truly carbon-free. The most important is outside car manufacturers' control. Whether or not an electric vehicle is greener than a conventional one is largely a function of how the electricity is generated. If it comes from dirty and inefficient coal-fired power stations, then the car will have a high "carbon footprint". If the power comes solely from renewable sources such as wind farms or solar plants, the car will be zero-emission.

In general, electric cars have a lower carbon footprint. But at the margins, a highly efficient small petrol-driven car could have less impact on the climate than an electric car fuelled from a grid made up mainly of coal-fired plants.

The Intergovernmental Panel on Climate Change found last year that even hybrid electric vehicles, depending on the design, could save between 20 per cent and 57 per cent of greenhouse gas emissions compared with standard cars. The UK's King review of transport emissions found that electric vehicles used with today's electricity generation mix could operate at a little less than 80 grammes of carbon dioxide per kilometre. A greatly increased use of renewables and nuclear energy, as well as coal-fired power plants from which the CO₂ is captured and stored, could see this fall to about 30 grammes per km, a fifth of what many cars achieve today.

Dong Energy, a Danish renewable energy company, recently announced a partnership with Project Better Place, an electric car infrastructure provider, to create conditions for a fleet of Danish electric cars. Anders Eldrup, chief executive of Dong Energy, says the high proportion of wind energy used in Denmark makes the cars much greener than they would be in many countries: "This is really taking carbon out of the picture."

Achieving a low-carbon electricity infrastructure is difficult but if greenhouse gas emissions from road transport are to be cut substantially, electric cars must play a large part. According to the King review, "fully electric, battery-powered vehicles, if using zero or low-carbon electricity, offer the most direct opportunity to decarbonise road transport over the longer term". The review found alternatives - such as biofuels, hydrogen or simply making existing cars more efficient - did not produce such high carbon savings.

At present, electric cars can be heavier than conventional equivalents because of their large batteries. Advances in battery technologies, however, should allow this weight to be cut. Using lighter materials such as carbon composites should also cut the amount of electricity required.

Caroline Öhrn, senior research analyst at Venture Business Research, says: "One can see a pollution issue related to the expanded use of batteries. They will require a considerable amount of recycling once the batteries are no longer usable."

Electric cars have other environmental benefits: they do not produce the particulates associated with burning fossil fuels. The American Lung Association found in a study that switching to electric cars in California alone would save at least \$2.2bn (£1.1bn, €1.4bn) a year in health costs related to people's exposure to fine particulate matter from conventional cars and that 300 cases of premature death, 260 cases of chronic bronchitis and more than 7,000 asthma attacks could be avoided each year as a result. They are also less noisy.

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