

The Evolution of the Hybrid Car

When a young Ferdinand Porsche took a job as a coach-builder near the turn of the 20th Century, he began a process that was to lead to the development of hybrid cars and provide a serious alternative to oil-fuelled combustion engines. While fuel-guzzling Porsches have fascinated the minds of petrol-headed fans the world over for many decades, now the Lohner Porsche Mixte Hybrid developed in 1900, which was the first gasoline-electric hybrid car in the world, is now being re-evaluated due to the inherent simplicity of his original design. It is what is part and parcel of what is at the heart of what is being manufactured today. His invention was essentially an electric vehicle which combined a conventional internal combustion engine system with an electric propulsion system.

There's something tragic however in the painfully long time Porsche's invention was mothballed for. It wasn't until the release of the Toyota Prius in 1997 that people in the automotive industry seriously began to take notice of this hybrid technology. Nearly a century passed before Porsche's concept car was given the critical attention it deserved. What other inventions there have been like this that have foolishly been put on ice, well, one can only wonder and grimace! This was a major oversight and there have surely been many others.

One of the main reasons for the mothballing of this hybrid car was due to the invention of the internal combustion engine and its reliance on refined oil to generate its mobility. Suddenly the car provided people with a freedom they had not experienced before and, as oil appeared to be quite plentiful, car manufacturers were happy to keep designing new models fuelled by plentiful supplies of oil. Oil was cheap and seemingly available in inexhaustible amounts, and at that time, the green movement was non-existent up until the early 1980s. This alone, to a large degree, is why there had been no real demand for hybrid cars.

A further reason for this lack of demand was due to the low priority given to the design quality of these vehicles. Recently, a British made prototype hybrid car appeared on E-bay, dating from the early 1980s. It was described as "a unique, one-off hybrid electric car...this vehicle represents the pinnacle of hybrid electric design" Indeed, the facts and figures seemed quite impressive. It had a top speed of 85mph, with 75mph when running solely on electricity. It had 4 modes of operation: battery only, series hybrid mode, engine only, and parallel mode. Its battery range of 40-50 miles would have made it ideal for urban driving. You get the feeling, though, that is was nothing more than a motorized bathtub made for collectors and connoisseurs and was not designed with the mass car market in mind.

Poor design or poor aesthetics have been one of the major factors manufacturers have had to overcome by dressing-up the appeal of hybrids for the general driving public. That's not to say all conventional cars have been gems in the good-looks department. It has definitely been the case though, that hybrid cars have always had to fight that much harder to get noticed amongst the established automotive manufacturers and their flashy combustion powered cars, while designers of hybrid

vehicles have tended to overlook what the car actually looked like, in favor of what goes on under the bonnet. However, after 100 years of stagnation, the hybrid revolution is now well and truly underway and setting new standards in the marketplace.

Examples of Popular Hybrid Models

Since 1997, the technology and the sources of energy that are used to power hybrid cars have undergone rapid development. There are now two distinct types of hybrid vehicles that are classified according to the way power generated by the motors, is transferred to the wheels to propel the vehicle forward and backwards.

The first type is parallel hybrids where an internal combustion engine and an electric motor are both connected to the mechanical transmission simultaneously to transfer power to drive the wheels. Honda uses this parallel system in its Insight, Civic and Accord models. The Insight was billed the cheapest gas-electric hybrid on the market and was ranked as the top-selling vehicle in Japan in April 2009, the first time a hybrid clinched that spot. During its first twelve months after its release, the second-generation Insight sold 143,015 units around the world. Parallel hybrids are also capable of regenerative braking which is an energy recovery mechanism that stores power for later use, and they are much more efficient than non-hybrid vehicles especially during the stop-start driving conditions experienced in urban areas.

The other main classification is the series hybrid where an electric motor directly drives the car forward and the internal combustion engine works as a generator to power the electric motor or to recharge the batteries. This type of hybrid vehicle usually has a smaller combustion engine, but a larger battery pack compared to parallel hybrids.

The Toyota Prius is the trailblazer of the hybrid car market. Its sales increased from a modest 300 units in 1997, to 19,500 in 2000, and by April 2008, its total sales worldwide reached the 1 million mark. By early 2010, the Prius total sales worldwide were estimated to be around 1.6 million units.

Once large car manufacturers began to realize they could make money from hybrid vehicles, they started to jump on the band wagon. The Ford Escape Hybrid, the first hybrid electric sports utility vehicle (SUV), was released in 2005, and in 2006 General Motors Saturn Division began marketing its own hybrid, the 2007 Saturn Vue Green Line series. Lexus released a hybrid electric version of their GS Sport in late 2008. The most popular hybrid cars are those labelled "full hybrids". These are cars that run on the engine alone, batteries alone, or a combination of both sources of power.

Why Hybrid Cars are so Popular

How can the revolution in the hybrid car market from one of relative obscurity up until the 1980s, to one of genuine global competitiveness today be explained? Is it

simply the case that our rapidly emerging environmental awareness as car consumers is driving this, or is there other factors at work?

There has been an interesting shift in the geography of hybrid car ownership. In 2007, the country with the highest proportion of global hybrid registrations was the USA with 70%, and Japan, the next biggest consumer, with a much lower 14%. This curiously went against the popular notion that Americans are gas guzzling maniacs who will never abandon their station wagons by choosing environmentally friendly vehicles. A closer look at these figures reveals some interesting statistics such as the hot-spots of sales for hybrid cars. On the east coast and environmentally conscious places on the west coast, particularly in California, they were high. However, over the next two years those percentages changed markedly with 45% of global hybrid registrations taking place in Japan and 39% in the USA.

This might only reflect the challenging economic circumstances people were going through following the financial crisis as much as it being a shift in people's environmental sensibilities. As Toyota and Honda continue to lead sales in hybrid vehicles, maybe this drop of hybrid sales in the USA was due more to American consumers choosing to buy locally made cars (both hybrids and standard vehicles).

What is clear though is that the improved fuel economy of these types of cars is a major reason why they are becoming increasingly more popular. The price of oil shows little sign of lowering in the near or later future, and as people's incomes are already being squeezed to an overextended degree, so much in current economic conditions, it makes sense that people are opting to make savings in those areas of life where there is significant cost involved.

Many hybrids these days get around 50 or more miles to the gallon and with their design and comfort improving all the time, it is a 'no-brainer' to see why this trend is taking place, particularly as the hybrid car industry has managed to perform such an image makeover for its product. No longer do consumers think they might have to plug their car into a power socket overnight to be able to use it next day. With full hybrids today, there really isn't much difference between these new technology vehicles, and the internal combustion vehicles they were used to with what they are replacing with today.

Perhaps the main reason for their increasing popularity is due more to a much stronger reason than global economics outlooks or marketing effectiveness. Our newly born concern for the environment that has swept most of the developed world in the last two or three decades has changed things a lot. We are more aware now than ever before of the environmental impact of almost every purchase we make. Whether it's the purchase of a cup of coffee or a holiday, the environmental movement has succeeded in making us think about the carbon footprint we make, and how we need to reduce our impact on the planet.

When buying a car, we put ourselves right in the firing line. We are made to think of the congestion and pollution that cars cause, the amount of resources and energy

that have been consumed in the manufacturing process to produce them (and incidentally to dispose of them at the end of their lifespan), and the awareness of the problems global warming is causing to the planet. And yet, the genie is well and truly out of the bottle as far as motoring is concerned as it gives us the freedom that we all crave. The hybrid car provides us with a very acceptable solution. It is a product that legitimises and increases consumerism while, at the same time, it is much kinder to the environment.

Barriers to Greater Hybrid Uptake

It's easy to assume that the on-going development of hybrid cars is going to be relatively trouble free, and the early assertions that they would only form a small proportion of the overall share of the car market is already proving to be a very flimsy premise. However, there are still some potentially significant challenges ahead that need to be addressed.

Ironically, most of these barriers are environmentally related. For all the positive figures on the falling carbon emissions and fuel economies being made with this new technology, there is a mounting concern about the environmental impact the type of batteries being used in hybrid cars are causing. These batteries are of two types, nickel metal hydride and lithium ion batteries, and both types do present problems. While batteries found in hybrids are far less toxic than standard car batteries, nickel based batteries contain carcinogenic substances. There is growing movement in the industry to minimize the risks posed by these batteries. Hitachi, for example, is attempting to develop more efficient lithium-ion batteries which should take the more hazardous nickel-based batteries out of the equation altogether.

Of greater long-term concern is the shortage of raw materials that is already starting to have an impact on the development of alternative batteries and many other key components in hybrid cars. The availability of, and the subsequent pricing of the little known rare earth element, dysprosium, has significant implications for the future of the hybrid industry. Dysprosium is required in the electric motors and battery systems of hybrid cars. Neodymium, another rare earth substance, which is crucial in fabricating the high-strength magnets that are found in permanent magnet electric motors, is also of concern.

Ironically, nearly all the rare earth elements in the world come from China. Just as the United Kingdom was able to exploit its coal reserves to great economic advantage at the start of the industrial revolution when it not only had the reserves of coal, but also the technology and know-how of how to mine, process and ship it, China finds itself in a similar position today. China is the chief supplier of these rare earth substances to the world and possesses an enormous amount of these hugely valuable natural resources.

Therefore, in industry circles, there is a feeling that this supply issue is something of a ticking time-bomb for the further development of hybrid cars. It seems that China is not over keen to open up its supply of rare earth elements to overseas interests as

is shown by its placing an export quota on these vital materials. Moreover, it is believed that an overall increase in general Chinese electronic manufacturing could well consume their entire total supply within the next few years.

Aside from the political and economic wrangling that is going as a result from this, there is also a serious environmental impact that is already being felt. There are areas of northern China that resemble some kind of industrial apocalyptic battlefield as increasingly damaging methods of extraction and processing are being employed to get to these rare earths. It is hard to accept the imagery employed in the slick marketing of hybrids while one is aware of the fact that so much environmental degradation is going on in the process to extract these substances.

Nevertheless, it is unlikely that the shift to hybrid cars is going to stall as a result of this as the major manufacturers have now invested heavily into this area. There is now something of a race to find non-Chinese sources of rare earth substances, as seen in the case of the Hoidas Lake project in northern Canada and Mount Weld in Australia which is presently being developed.

The fact remains, however, that there is massive capital outlay and investment required to find these alternative sources and with an increasingly stringent environmental standards that need to be adhered to, the barriers for new players to enter this field are very high indeed. The end result of this may mean a decrease in competition to develop these fields which could be bad news for consumers of these products. Where there is a lack of competition, it generally follows that prices are higher for products which can and does have a considerable flow-on effect.

Current Car Manufacturer Developments

Despite the looming supply issues caused by the dwindling reserves of vital raw materials, the philosophy of the major car manufacturers seems to be one of cashing in on the rising demand for the product now and worrying about the consequences later. The manufacturing of hybrids is no longer exclusively for the few, but has become commonplace throughout the industry. This is reflected in the wave of new models that have been introduced into the marketplace since 2009.

Hyundai has galvanized its domestic South Korean market with the launch of its own hybrid, the Elantra LPI. This is the first hybrid to be powered by an internal combustion engine running on liquefied petroleum gas (LPG) as a fuel. It also has adopted advanced lithium polymer batteries in response to concerns over standard nickel batteries.

Interestingly, more luxury manufacturers are adopting hybrids, with Mercedes Benz launching its S400 Blue Hybrid and BMW with its Active Hybrid 7, both in 2009. These manufacturers now realize that they can better their brand by adopting new types of hybrid technology. So in addition to new models being developed, their existing popular models are able to be fitted with hybrid engines.

A prime example of this is the launch of the Porsche Cayenne Hybrid in late 2010. As far as an effective counter-attack by car manufacturers against the environmental protection lobby, this is hard to beat. Suddenly, one of the high profile symbols of environmental damage, the 4x4, doesn't seem so nasty after all with a new seriously fuel efficient engine. Maybe this was what Ferdinand Porsche had in mind all along back in 1900. Porsche are playing it very safe initially though, as they have only launched it in the United States. Not to be outdone, Volkswagen announced at the 2010 Geneva Motor Show, the launch in 2012 of the Touareg.

Toyota is showing no signs of resting on its laurels and despite worldwide recalls of some of its more popular non-hybrids, after launching the Auris Hybrid in May 2010. This incidentally, was the first mass-produced hybrid vehicle to be built in Europe and is also significant in that the starting price is some \$800 dollars cheaper than the pin-up boy of hybrid cars, the Toyota Prius. Clearly, the race to develop hybrids has driven down the cost of these technologies. Peugeot also, has now joined in by developing the first production diesel-electric hybrid, the 3008Hybrid4. As it delivers an impressive 62 miles to the US gallon it illustrates how the technology is continuing to be improved.

One of the ways fuel consumption has been reduced since 2007 is through the application of regenerative braking technology. This enables energy that otherwise would have been lost during braking to be captured and stored to power electrical accessories such as air conditioning. Usually the energy used in the braking of a vehicle is wasted in the form of heat energy, but regenerative braking converts the vehicle's kinetic energy into battery-replenishing energy. There is also scope to increase the efficiency of hybrids through the use of their internal combustion engine to generate electricity by spinning an electrical generator to either recharge batteries or to directly power the electric drive motors.

Manufacturers are also actively featuring in their marketing campaigns the facility in hybrids that allows the engine to be shut down while idling when cars are stationary in traffic, and restarting when needed. As the perceived advantage of hybrids has mainly been focused on urban driving settings, this is a real bonus not only for the petrol paying motorist, but also for cyclists and pedestrians who benefit through the availability of cleaner air.

The fact remains however, that most hybrids use gasoline engines alongside their electric components, and this is expected to be the case for the foreseeable future. For the green credentials of the hybrid car industry to really stand up to scrutiny, surely the next challenge is to develop hybrids that don't rely on fossil fuels as their main power source, but use alternatives such as bio-fuels or hydrogen or even go entirely electric.

Hybrid Car Developments in China

Believe it or not, interest in greener options for motoring in China is gathering pace as the country works towards reducing pollution levels. The standard view of China

amongst many people is that it is a country pursuing economic growth at whatever the social and economic cost to the environment. The country is undoubtedly dogged by some of the worst air and water pollution from unregulated economic activity, however with a burgeoning middle class, maintaining the environmental quality might be the key to ensuring environmentally sustainable solutions are applied in China.

China is currently embarking on what it has called a 'New Energy' project. It seems they have realized that in spite of striking deals somewhat on the quiet in Africa for oil reserves, the price of oil continues to push skywards and that reliance on this most controversial of raw materials is clearly unsustainable. China continues to develop a power strategy based on relatively cheap and plentiful domestic coal reserves. However it is also investing in nuclear power in line with a desire to improve the quality of the environment.

What does this mean for the development of hybrid cars in China? The combination of a shying away from oil at a political level and having a continuing rise in disposable incomes means that the country could end up being the world's biggest market for battery powered cars. It's estimated that there could be 2.2 million vehicles on Chinese roads by 2020. This is a good example of a technology quantum leap. A similar thing is taking place in Africa as millions of Africans now own a mobile phone having never had a land-line. For China this means that millions of motorists go directly from conventional cars to pure battery vehicles, bypassing the hybrid versions altogether. Pure battery vehicles should be ideal for China because most motorists drive in urban areas rather than make long journeys.

While this may not, on the face of it, be great news for the hybrid market per se, there is going to be some time before pure battery cars are available to meet the demand of millions of new car consumers in China. So there is a window of opportunity for hybrid manufacturers.

Toyota is planning to start production of low-emission cars in China along with Geely Automobiles and Dongfeng Motor Group who plan to start production of electric and hybrid vehicles by the end of 2012. The latter has a target of selling 100,000 electric cars by 2015. Ford has also announced plans to introduce a test fleet of electric vehicles to the Chinese market later this year. There's something of a scramble among both domestic and international car companies to get a toe-hold in the market for low emission cars.

It will be interesting to see if the Chinese authorities, having committed themselves to improving their environmental record, are willing to offer incentives to both individuals and companies to make sure it happens. Or will there be preferential treatment for domestic manufacturers to the detriment of Chinese consumers?

Hydrogen Power as an Alternative to the Hybrid

Manufacturers can't afford to sit back and admire all the impressive work that has been done in making hybrids commercially viable and having people now wanting to buy them. They are now grappling with alternatives to the conventional gasoline engine that works in tandem with the electric component of a hybrid engine.

Biofuels:

Hybrid vehicles such as Ford's 2007 Escape Hybrid E85 use biofuels to power its internal combustion engine. Ethanol blending is widely used in the United States, Sweden and Brazil as an alternative to petrol, however its environmental credentials have been called in to question with its cultivation being cited as a direct cause of deforestation. There are those who argue strongly that the cultivation of bio-fuels takes up land that could otherwise be used to feed people.

Liquefied Petroleum Gas:

While it has been around for some time as an alternative to petrol its long-term viability in light of global warming has been called in to question. It is non-toxic, non-corrosive, free of tetra-ethyl lead and burns more cleanly than petrol but there is evidence that at low engine loads there is a significant increase in carbon emissions.

Pure Electric Cars:

These would eliminate the need to find a source of power for the combustion engine, but they require powerful batteries and the magnet material is prohibitively expensive given the current market in rare earth substances.

In light of these obstacles, hydrogen fuel-cell electric vehicles (HFEVs) such as the Honda FCX Clarity are providing a focus of attention. Hydrogen is able to be used in cars in two ways: as a source of combustible heat and as a source of electrons for an electric motor. Despite the abundance of hydrogen and its non-polluting properties when burned, the first of these options has never really been a practical option because of the fear of explosion by the highly flammable gas, plus the difficulty of carrying large amounts of fuel and the lack of a re-fuelling network. Consequently, hydrogen fuel cells are being looked at as a way of creating electricity that can be fed into an electric motor to drive a car.

It was reported that since the Honda FCX Clarity was first unveiled in November 2007, there were nearly 80,000 people who expressed an interest in owning one. Production costs of early models were prohibitive as they were in the region of \$1million. Since then, Honda has been able to cut its production costs to a more reasonable \$120,000 per vehicle. The car is still only available for lease in the United States, Europe, and Japan.

If you want one you'll need to get to Southern California as that is the state where there are "fast-fill" hydrogen stations. These highly innovative cars can be leased for US\$600 a month which includes accident coverage, maintenance, hydrogen fuel and

roadside assistance, which assuming you choose to drive the car out of California you'll need quite a lot. Currently the rate of expansion of hydrogen stations is painfully slow, which is obviously holding back the further development and uptake of the FCX as an alternative form of transport.

In one way the FCX project has got the feel of being a corporate experiment; granted, an interesting and fairly crucial one, even glamorous some might say. It's no coincidence that by heading for California, they've picked one of the global hubs of innovation. If a place can nurture ideas from companies like Apple and Google, then getting the hydrogen fuel-cell car going should be a foregone conclusion for Honda. There is a captive market in California with people only too ready to show their allegiance to this next generation of motor-car.

Honda believes that it could start mass-producing vehicles of this type by 2018, which is difficult to imagine given the challenges to overcome in relation to refueling stations. There is also an issue with the hydrogen being sourced from natural gas through a process of "steaming-out." In response to this, Honda could do with making a greater play out of the claims that the FCX Clarity is on a par in terms of CO2 efficiency with a battery car using electricity generated from burning natural gas, and much better than the same car using electricity from other states, (54% of which are generated by burning coal).

All of which brings the issue back to our starting point. The reason for the revolution in hybrid vehicles is as a response to the chronic energy crisis faced in many countries and the realization that car ownership is a desire shared by millions of people. Car manufacturers now realize that this is their *raison d'être*, and as a result have poured heaps of money into the development of this new technology.

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