Driving In Neutral

(New Automobile Ownership, Fuelling And Use Models)

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CarbonFree undertakes consultancy, research and analysis for vendors, investors and energy providers.

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The automobile addresses the consumer's hierarchy of needs at two levels. It satisfies a secondary need by providing a means to travel and, as a visible display of the owner's wealth and status, it also satisfies tertiary needs. Automobile manufacturers are well aware of the role their product plays within a modern industrial society, as evidenced by the way their marketing messages have evolved over the years. By addressing multiple needs, the large incumbent vendors have been able to dominate the transport market for almost a century. While there has been rationalisation and the integration of manufacturers into large groups, there have been few new entrants into a market that grew rapidly soon after petroleum became widely available.

Today, however, the automobile industry faces a number of serious challenges. Companies within the energy sector are desperately seeking alternatives to imported oil – the energy source around which most of the refuelling infrastructure that supports automobile use has been built. Automobile manufacturers themselves are attempting to develop new vehicles that are less dependent on fossil fuels. Meanwhile new players are entering the automobile market with products that are better designed to meet the consumer's tertiary needs at a time when there is widespread concern over the impact that emissions from automobiles are having on the environment. Incumbent manufacturers, who have maximised the market for the automobile by marketing them as both a practical tool and a fashion accessory, now see their business model under threat as 'green motoring' becomes fashionable.

There is also a change of sentiment within urban planning departments and other government agencies who, for many years, have taken a positive approach to automobile ownership and helped put in place much of the of the infrastructure that made the automobile indispensable for a majority of people. Today these same government agencies are designating areas of cities 'automobile free', encouraging new models of automobile use such as car clubs and are introducing parking restrictions and congestion charges.

Despite these factors, the next generation automobile vendors attempting to enter one of the largest markets in the world are finding it difficult to displace firmly entrenched incumbent manufacturers. Support infrastructure for fossil fuel power transport has been built up over several decades and replacing, or duplicating, overnight may prove prohibitively expensive. In addition, the incumbent vendors such as General Motors, Toyota and BMW are attempting to reinvent themselves and reposition themselves in a market they fear provides too many opportunities to new entrants.

This report is based on research into the companies and technologies that are creating new models for automobile ownership and use. Also within this report is an assessment of the new fuels, such as hydrogen, that next generation automobile vendors hope will provide the power for their products.

At a Glance

The automobile is marketed as both a practical tool and a conspicuous display of the owner's wealth and status, and as a result the motorist has steadily become dependent on the automobile to satisfy two levels of needs.

There are limits to the growth of the automobile market in the developed world as urban infrastructure growth fails to keep pace with vehicle use and the energy market approaches peak oil.

Globally there are concerns over the impact of automobile use on the environment and the contribution of carbon emissions to global warming.

Automobile manufacturers have used changing fashions and tastes to encourage motorists to buy new models, but were unprepared for the consumer's preference for smaller vehicles and hybrids. This has created a marketing opportunity for NextGen vehicle manufacturers.

This report examines emerging models within the automobile market and the opportunities they create for both incumbent and new entrants within the energy and transport industry.

Included in this report are profiles of: General Motors, BMW, ZAP, Lysander, Transport for London, Toyota, Chevron, Greenergy, CityCarClub and Honda.

1 Introduction – Time For A New Model

If the automobile did not already exist it is unlikely anyone would invent it in its present form. The fuel that powers it is a finite resource that is rapidly depleting and is mainly sourced from parts of the world where security of supply is an issue. The automobile itself is regarded as a key contributor to carbon emissions and has a negative environmental impact not only while it is being driven on the road but also during manufacture and, to a certain extent, when it is scrapped at the end of its life. The automobile is also a potentially dangerous means of transport and is implicated in the death or serious injury of over one million people each year. Like the cigarette, the automobile only remains on the market because it is such a compelling product and its use is so addictive.

If the automobile did not already exist it is unlikely anyone would invent it and manufacture it in its present form.

The oil and automobile industries have expanded in tandem and shared a long lasting relationship similar to the one that exists between Intel and Microsoft in today's high technology sector. The motor industry has also received significant support from government agencies that planned and deployed the infrastructure that encouraged the growth of private motoring. Suburbs, retail parks and industrial areas have been developed assuming people owned an automobile.

The automobile industry has faced serious challenges in the past. Ralph Nader led a long and hard fought campaign against it in the US during the 1960s, and the dramatic rise in oil prices in the 1970s led to a major restructuring of the industry. Despite this, it is still dominated by the companies who pioneered the mass production of petrol driven vehicles during the early part of the last century.

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The challenge the automobile industry faces today is more serious as it has its roots in the inability of the oil industry to produce a reliable and low cost and carbon emission free product. This is putting the relationships between transport planners, oil producers and automotive industry under pressure. If the erosion of these relationships continues, niche automobile vendors could see rapid growth in the number of companies who are building products and services based on alternative fuel and vehicle use models.

Consumer sentiment may also have a significant impact on the automobile market. While a large majority of motorists remain passionate about automobile ownership and use, there is a subtle shift in attitudes that sees some people using private transport as a means of displaying their 'green' credentials. This sometimes impacts on the particular vehicle they purchase or sometimes on whether they own a vehicle at all. A small number of these consumers are already experimenting with alternative automobile use models.

The government agencies who once took a neutral and, in some cases, a positive stance on automobile use are also changing their attitude to the automobile industry. Increasingly these agencies are putting in place measures that control and limit the use of the automobile. Governments are also intervening in the transport market by introducing legislation that favours vendors who have developed new ways to fuel automobiles, and organisations that design and operate alternative use and ownership models.

There are also strong signs of a change in sentiment amongst government agencies who once took a neutral, and in some cases a positive, stance on automobile ownership and use.

A number of new business models are emerging within the automobile market that impact on fuelling, ownership and use of private vehicles. The challenge for both the incumbent manufacturer and the new entrant into the automobile market is to position their business to take full advantage of these models.

2 Emerging Models

There are three emerging models for automobile use and each has a potential impact on the economies of developed countries and provides opportunities for manufacturers and transport service providers.

2.1 The 'As Is' Model

This model assumes there will be only incremental changes within the automobile sector. It is quite possible that this model is workable well beyond peak oil. At that point, the increasing price of fossil based fuels will force the motorist to consider alternative models for personal transport and to reassess whether the ownership of a large vehicle with a high fuel consumption or more than one vehicle is economically viable. For government agencies, letting market forces encourage motorists to consider new models of automobile ownership is a simpler option than forcing them to modify their behaviour – which courts unpopularity and sometimes leads to governments losing office.

The 'As Is' model assumes there will only be incremental changes within the automobile sector. It is quite possible that this model is workable until the energy market achieves peak oil.

In the short term, the 'As Is' model also suits the automobile manufacturers, who can continue to maximise returns on past investment in research and development and manufacturing plants. It also fits well with well-established product distribution and supply channels. The model also suits the oil industry for the same reasons.

The risk associated with the 'As Is' model is that increased congestion and emissions will cause both economic and environmental damage before peak oil is achieved. The Stern Report attempted to assess the economic impact of the environmental damage caused by carbon emissions. It is relatively simple to calculate the cost of congestion and also easy to explain this to the motorist who usually has first hand experience of travel delays caused by traffic jams.

Congestion causes most direct and measurable economic damage in industrial countries, most of which risk seeing their competitiveness eroded as transportation costs and lost man-hours due to travel delays increase. Emerging countries with lower automobile ownership rates could gain a competitive advantage here. An associated risk, for industrialised economies, is that emerging economies might build their transport infrastructure around new automobile ownership and use models. This divergence of transport models between industrial and emerging economies could have a serious impact on the automobile industry. Key innovations in private transport technologies and services could start appearing in emerging, rather than developed, countries. To some extent this is already happening in the solar energy and sustainable building sectors, with China putting in place large building programmes that have created a substantial market for companies who are developing building-integrated solar systems.

Congestion causes most direct and measurable economic damage in industrial countries. These countries run the risk of seeing their competitiveness eroded as transportation costs and lost man-hours due to travel delays increase.

A country where vehicle ownership is low has the opportunity to consider new models for automobile ownership and use. This could provide that country with a long-term economic advantage over a developed country that is persisting with the 'As Is' model and is following the evolutionary path of the fossil fuel driven vehicle, and its associated infrastructure, to its conclusion.

The key disadvantage of the 'As Is' model is its unpredictable and uncontrolled outcomes. Many of the political and social tensions that result from attempts to control the use of the automobile will not go away just because governments go out of their way not to provoke them – or point to the declining availability of oil as a reason why fuel prices rise beyond the reach of the motorist. Solving the problems associated with the automobile sector is possibly the largest change management exercise the world has ever seen.

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2.2 The New Fuel Model

In the pioneering days of the automobile, petrol was not the obvious fuel of choice. Early vehicles ran on steam produced by burning wood or coal. Others ran on biofuels produced from crops, and some manufacturers experimented with electricity driven vehicles. Fossil fuel oil was a contender even though the distribution model for benzene itself was still based on the one used to supply consumers with oil for heating and lighting. Before the development of the filling station, there were a number of serious accidents and cases where cans of fuel stored in small corner shops started major fires in built up areas. However, the availability of oil, and the need to find a profitable outlet for the new fuel, motivated oil companies to find a way to overcome problems associated with its distribution.

The New Fuel model could end the relationship between the oil producer and the motor manufacturer, which is currently similar to the one that exists between Microsoft and Intel in the high technology industry.

The relationship between the oil producer and the motor manufacturer developed along similar lines to one that grew up between Microsoft and Intel in the high technology industry – both parties have jointly marketed a concept that has been readily accepted as a de facto standard by a majority of users and third party suppliers.

Today the automobile industry is looking for a 'New Fuel' model that will sustain its business beyond peak oil. Some of these models look radical but represent only a step change and leave the relationship between the oil producers and automotive industry relatively intact. Others are truly disruptive and could see a century old partnership draw to a close as the automobile industry starts working with new partners in the energy sector. For this reason, the New Fuel model represents both risks and opportunities for both incumbent and next generation automobile manufacturers alike.

2.2.1 Biofuels – A World Without Fossil Fuel

It is interesting to consider a scenario where the ability to extract benzene from fossil fuels was overlooked or ignored and all automobiles were powered by biofuels derived from a range of crops such as oilseed rape, palm oil and maize. How would the automobile industry, the energy sector and, for that matter, global economies have developed assuming such a scenario existed?

It is interesting to consider a scenario where the ability to extract benzene from fossil fuels was overlooked and automobiles were powered by biofuels derived from a range of crops such as oilseed rape, palm oil and maize.

It is estimated that over 50% of Europe's cereal production would have to be allocated to biofuel production if all motor fuels had a 10% biofuel content. This means that, if *all* motor fuel were biofuel based, cereal production would have to increase to five times its current level – assuming it was all used to manufacture biofuel for transport. This then sets an absolute maximum for the size of the European automobile sector at five times smaller than it is today – if Europe were self sufficient in motor fuel. In reality the automobile industry would be even smaller than this, as cereals and oils would still be required for food and, in the absence of fossil based oil, plastics and chemicals.

The automobile industry would be smaller if it shared its source of energy with the global food industry.

On the other hand, a focus on the production of fuel from crops would encourage innovations in biotechnologies and it is quite likely that farmers would then be growing crops far more advanced than the 'second generation' biofuel feedstock currently being developed.

Even so, if fossil based oil had not been available, the automotive industry and the US economy itself would have experienced a slower and possibly steadier rate of growth, with the agricultural sector playing a dominant role. The infrastructure of countries throughout the developed world would be radically different than it is today, with fewer highways and denser urban development.

Fossil fuel extraction and production is concentrated in small geographical areas – even when it is located above large oilfields. However, biofuel production requires the management and control of large areas of land. A world economy based on the production of biofuels would have a radically different geopolitical structure than the one that exists today, and consumer nations in the developed world would have less scope for exerting dominance over producer nations in the developing world. (See the CarbonFree report "Farming Renewable Energy".)

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Despite experiencing lower growth rates, and having infrastructures less geared towards automobile use, economies of developed countries would be placing severe strains, both economic and environmental, on the global agricultural system. Most consuming countries would regard themselves as vulnerable to disruptions in energy supplies. This insecurity would emanate from regional conflicts over the use of land and crop failures.

Today, within the 'As Is' model, the key stated aim of biofuel use, the reduction of CO_2 emissions, is often not met, as carbon based fuels are burnt to provide the energy needed to process the feedstocks on which biofuels are based. In a majority of cases, burning the crops in a raw state to produce energy to power electric vehicles would have a greater impact on automobile industry related carbon emissions.

Biofuels have the advantage of fitting well with the distribution infrastructure used to supply motorists with conventional automobile fuels such as benzene and diesel and have the potential to postpone peak oil for a number of years.

Biofuels fit well with the distribution infrastructure that is used to supply motorists with conventional automobile fuels such as benzene and diesel.

However, biofuel use is not disruptive enough to be regarded as a component in a 'New Fuel', as its adoption as such would merely be replacing one form of energy insecurity with another. The transport infrastructure of the developed world is too large to be sustained by biofuel production alone, and the environmental and economic damage caused within producer countries would be unacceptably high.

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Example – Greenergy

Approximately 50% of the feedstock processed by UK based Greenergy is expected to come from rapeseed oil, and the rest from soya and palm oil imports and waste cooking oil. It plans to import soya from South America, but has not stated where the palm oil will come from. Its plans to import soya and palm oil have caused some controversy given that the farming of these products has been responsible for a large proportion of deforestation, especially in Indonesia and Malaysia which account for 80% of the global palm oil market, but also in Colombia and Cameroon. Similarly, soya production is the main cause of deforestation in Paraguay and Argentina. According to a study by WWF, Brazil's sugar ethanol programme is causing deforestation in the Atlantic Forest, and specifically in the State of Alagoas, where only 3% of original forest cover remains.

Furthermore, rain forests around the world in which these crops are grown also have the highest levels of biodiversity, and the farming of oil crops threatens this diversity and the endangered species living there.

2.2.2 Electricity – The Automobile As An Appliance

Electric vehicles are not new and batteries have been used to power small commercial vehicles – for example milk delivery trucks – for several decades. Traditionally these vehicles have been slow and had a limited range. However, recent advances in battery technology have encouraged the development of a new generation of electric powered cars, trucks and motorbikes. Work on many of these new models began when the current round of energy price rises started and governments introduced carbon emission reduction strategies. Now investors are beginning to see the results of the funding they provided for 'NextGen' vehicle makers as production models reach the market.

Recent advances in battery technology have encouraged the development of a new generation of electric powered cars, trucks and motorbikes.

Electricity is a form of energy rather than a fuel. Today, this energy is produced in a fossil fuel burning or nuclear powered generation plant, then delivered to the motorist via a power grid. The motorist recharges their vehicle by connecting it, overnight, to the mains.

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Hybrid automobiles provide a halfway house between the pure electric and the fossil fuel powered automobile. The hybrid captures and reuses energy that would otherwise be wasted when the driver applies the vehicle's brakes, and can also be charged from the mains electricity grid.

There are currently several Japanese and American production hybrid vehicles available to consumers at affordable prices, although still more expensive than their conventional counterparts. Some models have configurations that allow electric-only operation at low speeds. Some, like the Prius, can operate in mixed mode where both the internal combustion engine and the electric motor are used simultaneously to increase fuel mileage for a particular range. DaimlerChrysler is currently building plug-in hybrid electric vehicles based on the Mercedes-Benz 15-passenger Sprinter van. Light trucks are also offered by Micro-Vett SPA. General Motors plans to introduce a production plug-in hybrid electric vehicle version of Saturn's Greenline Vue sport utility vehicle (SUV) in 2009.

There are currently several Japanese and American production hybrid vehicles available for consumers at affordable prices, although still more expensive than their conventional counterparts.

Abandoning fossil fuel powered automobiles in favour of electric automobiles will do little, in the short term, to reduce the dependence of the transport sector on fossil fuels. The main immediate benefit of electric vehicles is that emissions from the burning of the fossil fuels that ultimately provide their power are produced at a few power stations rather than at millions of individual locations within urban areas. This, in theory, should make it easier to capture and sequestrate carbon emissions. However, the energy losses incurred as electricity is delivered over the grid system need to be taken into account when calculating any savings in centralising the generation of energy for the transport sector.

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While it is possible to generate a certain amount of power using wind and solar energy systems, there is already a steadily rising demand for electricity in most developing countries. It is unlikely renewable energy providers will be able to meet demand if the transport sector starts to draw its energy from the same source as residential and industrial users. While nuclear power stations could provide the energy for electric vehicles, the opposition to the building of new plants will result in a significant delay in providing the energy needed to support any significant growth in the use of electric vehicles.

Any shift towards the widespread use of electric vehicles would result in a new player entering the transport sector, with the power generator replacing the oil company as supplier of energy to the motorist. This would impact on the oil companies themselves who would see a falling demand for their product – and fewer consumers using the infrastructure through which benzene and diesel are delivered. For the power generator the cost of entry into this market is low as the infrastructure necessary to deliver energy to the motorist's home or place of work is already in place. There would also be an impact on the automobile manufacturers, who would see NextGen vehicle makers not only selling automobiles as appliances but in some cases entering into distribution and marketing arrangements with electricity providers.

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2.2.3 Hydrogen

Hydrogen, like electricity, should be regarded as a store of energy rather than a fuel. Currently most hydrogen is produced using fossil fuel based energy systems, although some companies (see the CarbonFree report "Watts in Store – Storing Renewable Energy") are experimenting with hydrogen refuelling stations where the gas is produced on site using electrolysis powered by wind energy.

However, most methods currently employed to produce hydrogen are expensive and inefficient in energy terms. As with electric powered vehicles, there is some advantage in centralising the production of carbon emissions to aid capture and disposal, but in most cases there is no significant net reduction in emissions when using hydrogen to power automobiles.

As hydrogen is volatile, and leaks through metal, the storage and distribution of the gas is a challenge for the motor industry. BMW has developed a combined hydrogen and benzene powered car that is based on a conventional fuel distribution model and uses roadside filling stations. Another automobile manufacturer, Honda, is working on a distribution model where a householder has a small hydrogen storage system that is used both to refuel their car and provide the fuel to heat and power their home. Both approaches require a large investment in infrastructure. While BMW's system requires the hydrogen supplier to build a network of refuelling stations, with Honda's system the consumer would contribute to the cost of the home refuelling station.

As hydrogen is volatile, and leaks through metal, storage and distribution is a challenge for the motor industry. While a range of different distribution models have been piloted, most are still based on the conventional filling station.

Hydrogen receives enthusiastic backing from NextGen energy providers who see it as a potential disruptor within a market dominated by entrenched players. A series of steep increases in crude oil prices have seen a revival of research programmes investigating ways to produce and distribute hydrogen. Despite this, hydrogen production and the refuelling infrastructure to support hydrogen powered vehicles is as primitive and inefficient as gasoline distribution was when the first automobiles took to the road in the late 1800s. Whereas the number of automobiles in use a century ago could easily be supported by a refuelling system based on purchasing cans of gasoline in a high street store, today there are many millions of motorists who expect refuelling of their automobile to be quick, easy and safe. It could be two decades before hydrogen meets these criteria.

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Example – Chevron

Chevron has operated a hydrogen energy station since February 2005 in collaboration with Hyundai Motor Co. and UTC Fuel Cells. The project is part of the US Department of Energy's Controlled Hydrogen Fleet and Infrastructure Demonstration and Validation Project, a five-year cost-sharing programme designed to demonstrate safe and practical hydrogen technologies in real-world settings. This station is one of up to six that Chevron plans to establish. The station is located at the Hyundai-Kia America Technical Centre in California, USA and produces, compresses, stores and dispenses hydrogen on site. It produces hydrogen from natural gas, and is also capable of producing hydrogen from corn-based ethanol. The station stores 100 kg of hydrogen in pressurised containers – enough fuel to support up to five fuel cell vehicles. The hydrogen dispenser is designed to simultaneously fuel two vehicles in three to five minutes.

Example – BMW

The German premium automobile manufacturer has produced a hydrogen-powered version of its top-of-the-range model, the BMW 7 series.

The combustion engine in the 'Hydrogen 7', a derivative of the 7 series 12 cylinder engine, is capable of running on petrol or liquid hydrogen, produces 191 kW, and accelerates from 0 to 62 mph in 9.5 seconds, with a top speed of 230 kph. The hydrogen storage tank has a capacity of approximately 8 kg of liquid hydrogen, giving the Hydrogen 7 a cruising range of more than 200 km. The petrol mode provides an additional 482 km of cruising range, giving a total range of approximately 680 km. The engine power and torque remain identical regardless of the fuel used, and the car provides a smooth transition between the modes at the touch of a button – the decision about which fuel to use being made by the driver.

The by-product of the engine's combustion process is almost exclusively water vapour. However, some nitrous oxide and carbon dioxide are emitted, which means that the Hydrogen 7 is not a zero-emission car.

2.3 The New Use Model

During the next two decades the automobile sector will employ a combination of the 'As Is' and New Fuel models. It is unlikely that, in the absence of a major innovation, hydrogen will fill the gap that will open up between the supply and demand for auto fuel in a post-peak-oil energy market. It is also unlikely that enough land area can be set aside for biofuel production to replace dwindling oil supplies. This means that, in the medium term, the automobile industry will be dominated a combination of three models; 'As Is', 'New Fuel' and 'New Use'.

Government agencies are the key proponents of the New Use model and are putting in place various programmes that attempt to discourage automobile use by charging drivers for some, or all, journeys they make in their vehicles. These programmes are proving unpopular with motorists, and governments face strong opposition, from a range of special interest groups, to the deployment of any new models for automobile use.

Government agencies are the key proponents of the New Use model and are putting in place various programmes that attempt to discourage automobile use by charging drivers for either some or all journeys.

In the absence of concerns over the impact on the environment of emissions from automobiles, governments could have left the road transport sector to the mercy of market forces. Rising energy costs, and the scarcity of crude oil, would eventually price a large number of drivers off the road, forcing them to use alternative modes of transport or to make fewer journeys. However, congestion in urban areas and confirmation that the automobile is contributing to global warming has forced governments to take action.

Government agencies are notoriously bad at marketing new services to the public – who often suspect that any new transport model is merely designed to raise additional tax revenue. However, these agencies are not the only organisations who are attempting to build alternative models of automobile use.

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2.3.1 Restricting Use

A number of government transport and urban planning agencies are attempting to reduce automobile use.

Transport for London, in the UK, have introduced congestion charging which involves drivers being charged a set amount for entering the centre of London at a certain time of day. There are plans to introduce the scheme in other UK cities and eventually build a road charging system whereby a motorist pays for car use on a per mile basis. The charges would be determined by the route the driver takes and the time of day they travel. In other parts of Europe similar systems are under consideration – all involve tracking the car using combinations of roadside cameras, wireless sensors and satellite navigation systems.

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City planners are also attempting to limit the motorist's propensity to use an automobile. Retailers are being dissuaded from building out-of-town shopping centres that can only be accessed using an automobile, and automobiles are excluded from large areas of city centres by rising bollards that are only lowered when approached by a bus or taxi. Companies are finding that planning applications for offices are rejected unless car parking spaces are kept to a minimum.

In a move aimed at reducing emissions rather than limiting congestion, some city authorities levy higher parking and access charges for SUVs, that have a high fuel consumption, while providing free access and designated parking spaces for electric vehicles.

In a move aimed at reducing emissions rather than limiting congestion, some city authorities levy higher parking and access charges for vehicles, such as SUVs, that have a high fuel consumption, but provide electric vehicles with free access and designated parking spaces.

Transport planners hope that the public will abandon their automobiles in favour of public transport. There are a number of reasons why it is proving difficult to migrate people from automobiles to public transport.

- Several decades of low investment in public transport means that mass transit systems are either not available in the locations required or, if they do exist, they are already working to capacity.

- Mass transit systems do not provide the granularity that the modern developed economy has come to depend upon.

- Automobile ownership has both practical and emotive components. Many drivers need an automobile to commute to work and to collect goods from out-of-town stores, but the automobile also offers them freedom and provides a conspicuous display of their wealth and status.

Over the last century the automotive industry has spent billions of dollars marketing the benefits of vehicle ownership and use. Short sharp campaigns to persuade the automobile owner to find alternatives to vehicle use will have little impact – especially if the consumer cannot see any immediate benefit in changing their behaviour.

Unless public transport systems are well used they offer no real benefits over the automobile for either the consumer or the transport planner. A slow moving bus with a fuel consumption of ten miles per gallon of diesel and only carrying five passengers does little to reduce emissions, congestion or the economy's dependence on oil.

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Example – Transport for London

There is a proposal to add emissions-influenced charging to the London congestion charging scheme. According to the proposal, the most polluting cars, i.e. those emitting more than 225g/km of carbon dioxide (equivalent to Vehicle Excise Duty (VED) band G), will be charged $49 per day; those emitting between 121 and 225g/km (VED band C–F) or those for which carbon dioxide emissions data are not available will pay the standard charge of $16 per day; and those emitting up to 120g/km and that are Euro IV conformant (VED bands A and B) will not pay anything. London residents with cars in bands A and B will not pay anything. Those with cars in bands C–F would be given a 90% discount; and those with cars in band G would pay the full charge. The plan is to put these proposals in place from 2008 following stakeholder and public consultations in 2007, replacing the existing Congestion Charging Alternative Fuel Discount.

Another proposal, to designate Greater London as a low emission zone from 2008, has already undergone stakeholder consultation. If this proposal meets with approval, diesel lorries, coaches and buses that fail to comply with emission standards for air pollutants will pay a daily charge.

2.3.2 Social Use

There are alternatives to both public transport and automobile ownership. The Internet and the World Wide Web are providing a platform for new services such as car clubs and lift sharing.

There are alternatives to both public transport and automobile ownership. These have their roots in ad hoc and informal lift-sharing schemes and are now, with the growth of online communities, gaining momentum.

Car clubs provide members with access to an automobile, which is available at a pick up point and can be booked online for a specific period. As the schemes are structured at present, the automobile must be returned to a specific pick up point. The member is freed from the responsibility for maintaining the vehicle or finding somewhere to park it when it is not in use. At present, car clubs are only workable in urban areas, and while they have nationwide booking systems, on the ground they tend to operate locally.

While car clubs are suitable for people who require transport for one off journeys – for example a shopping trip or a business meeting – they are not ideal for commuting during peak periods when vehicle availability becomes an issue. An alternative here is the lift-sharing service, which operates along similar lines to informal schemes that were popular before car ownership became ubiquitous. The donor of a lift posts their journey on a web site and the consumer books the journey then shares the cost with the donor. Online lift-sharing services have the potential to widen the scope of the service and offer the consumer greater choice and flexibility.

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Both lift-sharing services and car clubs receive support from transport planners and local government in urban areas, while some car clubs have also attracted private investment. Such services add intelligence to an existing transportation model.

Mass transit operators are also active in this space and some have fragmented small parts of their networks by offering services such as 'dial a bus' where the exact route of a bus is determined by passengers who request a journey via a telephone. There is scope to continue adding intelligence to the private and public transport system and to blend the operation of the two – eventually making journeys using different modes of transport seamless and simple to book.

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3 Governments And The Automobile Market

Throughout the developed world the relationship between government and the automobile sector is far from benign. Government agencies have overseen the development of infrastructure that encouraged automobile ownership. Suburban conurbations have been developed in areas poorly served by mass transit systems and which now depend on the privately owned automobile to transport workers either into the city or to nearby industrial and commercial areas. Automobile ownership grew as manufacturers took advantage of economies of scale and lowered vehicle prices in real terms – the automobile became more affordable and ownership ubiquitous. Within cities, planners increasingly overlooked the provision of public transport and mass transit infrastructure when allowing the growth of commercial developments such as office blocks and shopping malls. Government took the view that automobile use was beneficial for the economy.

Throughout the developed world the relationship between governments and the automobile sector is far from benign. Government agencies have overseen the development of infrastructure that encouraged automobile ownership.

Near-ubiquitous automobile ownership benefits both national and local governments in two ways:-

- A strong domestic market for automobiles encourages employment within the manufacturing sector and supports vendors who also export vehicles and, in doing so, boost the gross domestic product of the region. For example the Hyundai Company alone accounts for 4.6% of the exports of South Korea, and one in seven jobs in Germany is supported by automobile production.

- Automobile use provides the labour market with a level of flexibility. Freed from constraints imposed by mass transit systems, people can work in small units remote from industrial centres. If used for delivery of goods, small vehicles add granularity to logistics systems. As a consequence, businesses can grow rapidly in areas where rents and property prices are low and the size at which a business is viable is smaller than it would be if workers and goods were transported by rail.

However, many developed countries are experiencing diminishing returns from automobile ownership. As automobile use increases, so does the pressure it imposes on the transport infrastructure. Few governments in the developed world have been able to fund the road building programmes required to prevent congestion. A classic case has been the M25 ring road around London, which was built to relieve pressure on the roads in the UK's capital. Within two years of opening, the ring road itself was experiencing congestion, and the time taken for an automobile to travel one mile within London continued to rise.

Within two years of opening, London's ring road was itself experiencing congestion, and the time taken for an automobile to travel one mile within the city has continued to rise.

Modern automobile production is highly mechanised and globally distributed. Automobile manufacturers are moving parts of their operations to developing countries to take advantage of what they regard as a key growth market. In the US and Europe, domestic manufacturers are being displaced by foreign owned non-union companies that have less influence over governments.

In the US and Europe, domestic manufacturers are being displaced by foreign owned companies that have less influence over local governments.

In general the fewer automobiles a state or country produces, the less supportive its government is of automobile ownership. In the USA this can be observed in the widening gulf in the policy adopted towards automobile use by the governments of Michigan and California. With Detroit based automobile manufacturers making a significant contribution to the economy of Michigan, the state is remaining supportive of automobile ownership. However, California feels it is experiencing rapidly diminishing returns from automobile ownership, which, by causing pollution in heavily populated areas, is driving up the cost of healthcare in the state as people seek treatment for respiratory illnesses. Congestion in commercial areas of California, such as Silicon Valley, has reached the point where lengthened journey times are outweighing some of the benefits of automobile ownership – both for the owner and for the company that employs them.

In addition, Silicon Valley is now home to a number of companies that provide alternatives to the petrol powered automobile, and both these companies and, as a consequence, the economy of California would benefit from any market shift away from the fossil fuel powered vehicles currently manufactured in Detroit.

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California has introduced measures ranging from special highway lanes for shared vehicles to strict emission controls for cars imported into the state. In theory, these initiatives should discourage automobile ownership and use. In reality, however, decades of infrastructure development based towards automobile use at the expense of investment and innovation in mass transit and public transport systems means that, even where they exist, the alternatives to the automobile cannot cope with a sudden increase in demand. California is a prime example of a highly developed economy that is highly vulnerable as the energy market approaches peak oil, with large parts of the state, including key commercial centres, only accessible by automobile.

The automobile manufacturers have, for a number of years, been aware of the government transport and urban planner's changing attitude to automobile use and have shifted their marketing message accordingly. As the practical benefits of car use decline, due to reduction in parking spaces and congestion charging, the manufacturers place greater emphasis on the benefits of automobile ownership rather than vehicle use. The resulting emotional attachment the present day motorist has to their vehicle makes it difficult for transport and urban planners to migrate people from car use to public transport. Many initiatives result in confrontation between government agencies and automobile user groups.

The motorist's emotional attachment to their vehicles makes it difficult for transport and urban planners to migrate people to public transport and often leads to confrontation between government agencies and automobile user groups.

The problems government agencies encounter when intervening in the automobile market are illustrated by the difficulties the EU Commission experienced when it drafted a transport policy that included cuts in emissions.

German manufacturers who focus on the production of large automobiles lobbied against the original targets for emission reductions, claiming that they would bias the market towards manufacturers in France and Italy that specialise in the production of smaller models with lower emission ratings. The UK government is also experiencing a backlash against proposed plans to introduce a nationwide road changing scheme, with over 1.5 million people signing an online petition against any move to introduce a pay per mile automobile use model.

German manufacturers who focus on the production of large automobiles lobbied against the original targets for emission reductions, claiming that they would bias the market towards manufacturers in France and Italy that specialise in the production of smaller models.

When road charging schemes are implemented at a national level, the public suspect that they are merely tax-raising initiatives and that the funds raised will be used to cover deficits in other, non-transport related, government spending programmes. The UK's road charging scheme has been proposed at a time when the country's public healthcare service is in deficit and a number of other government spending programmes require additional funding. In London itself it has been easier to demonstrate that parking and congestion charges are funding an upgrade to the city's transport infrastructure. However, the national government has also contributed to this upgrade – not something it could afford to do across the whole of the UK.

Governments in the developed world face a range of other issues related to automobile use. One of these is a growing problem associated with the demographic profile of today's automobile owners and drivers. As a person ages, their eyesight deteriorates and their ability to react quickly in fast moving situations is reduced. This is happening to an increasing number of motorists at a time when traffic volumes are growing and the performance of vehicles in terms of speed and acceleration is increasing. There have been suggestions that, for their own safety, older drivers should either submit to regular driving tests or, on reaching a certain age, surrender their licence. Such legislation would prove controversial and any government attempting to introduce it would lose a significant, and perhaps crucial, level of support. Many of the issues relating to private transport and the elderly are similar to those that impact on other automobile use models – in particular a lack of supporting infrastructure for alternative means of transport. For this reason, governments may be forced to consider all aspects of automobile use at the same time and build a model that is both comprehensive and workable.

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4 The Manufacturer And The Automobile Market

The global automobile sector is entering a period of restructuring. Toyota is poised to replace General Motors as the world's largest manufacturer. A sudden rise in the oil price has seen large US based manufacturers, who have failed to produce smaller more fuel-efficient models, losing market share to Far East and European manufacturers. For Ford, General Motors and Chrysler revamping a diverse product range, which is spread over numerous brands, would prove prohibitively expensive. Incumbents within the automobile industry would need to carry out this restructuring at a time when earnings are being used to fund generous healthcare and pension plans negotiated by former employees. It is perhaps little surprise that incumbent players have paid too little attention to new entrants with innovative products and services.

A sudden rise in oil prices has seen large US based manufacturers, who have failed to produce smaller more fuel-efficient models, losing market share to Far East and European manufacturers.

Even though the NextGen automobile companies' products or services may prove highly disruptive to the business models of the incumbents, major automotive manufactures have little choice but to concentrate on producing vehicles designed to fit the 'As Is' model.

Even a new entrant to the automotive market, building a plant on a greenfield site, would do well to assume an 'As Is' model. While oil prices may rise significantly in the run up to peak oil, governments throughout the developed world will do their utmost to ensure the price of fuel at the pump remains as low as possible. These same governments will, using diplomacy or in extreme cases military intervention, endeavour to ensure supplies of crude oil are secure.

While oil prices may rise significantly as the energy market approaches peak oil, governments throughout the developed world will do their utmost to ensure the price of fuel at the pump remains as low as possible.

The automobile industry is the oil industry's key customer (19.4 gallons of gasoline are extracted from every 42-gallon barrel of oil), and oil companies will work hard to protect this market. As supplies of easily extracted oil diminish, oil companies will expend significant effort helping the automotive sector to reduce fuel consumption. It is quite likely that, for the automobile driver at least, the energy market will appear to change little over the next two decades. Twenty years is a sufficient period for a modern automotive plant to pay for itself and provide a return for investors.

Most of today's large automobile manufacturers are direct descendants of the pioneers of the industry. Daimler Benz can lay claim to inventing the automobile, while Ford were the first company to mass produce a model that was cheap enough to sell in quantity. The cost of entry, in terms of plant and engineering design, along with the inability to achieve scale within a typical investment cycle, meant there have been few new entrants in this highly restrictive market. The specialist manufacturers that have emerged over the years concentrated on customising models produced by one or more of the major players. There were limits to how large the market for these new entrants grew before their senior partner took a controlling interest or merged the new entrant into their own enterprise.

The cost of entry, in terms of plant and engineering design, along with the inability to achieve scale within a typical investment cycle, meant there have been few new entrants in this highly restrictive market.

4.1 The Impact Of The New Fuel Model

A new entrant that bases its product on an alternative fuel model could, even in the short to medium term, disrupt the business models of incumbent automobile producers. In the US this has been clearly demonstrated with the Toyota Prius. Timing was an important factor governing the success of Toyota's hybrid car, which was launched at a time when concern over energy security was at its height. However, for several decades the incumbent players in the automotive market have been promoting their products as a form of fashion accessory. This was necessary to ensure that the consumer replaced their vehicle well before it reached the end of its useful life. The consumer's original vehicle would enter the second user market, and the manufacturer would earn revenue by selling the consumer a new model.

A new entrant that bases its product on an alternative fuel model could disrupt the business models of incumbent automobile producers. In the US this has been clearly demonstrated with the Toyota Prius.

Fashion has become an important driver in a market that was approaching saturation. Unfortunately for the incumbent, concerns over the impact of automobile emissions have made a display of 'green' credentials fashionable.

This shift in attitude is already influencing purchasing decisions. Like the customised high performance automobile, a hydrogen or hybrid fuelled vehicle can enhance the image of a vendor's brand. While it is currently impossible for fuel companies to deliver alternatives to benzene or diesel, having a hydrogen or electric version of a particular model is beneficial for the automobile manufacturer. This 'greening' of the brand is similar to the 'performance by association' marketing that uses custom performance vehicles to promote standard models. Even though most consumers do not drive their conventional Mercedes at 250 miles per hour, they are attracted by the association of their vehicles with high performance models sold under the same marque.

Like the customised high performance automobile, a hydrogen or hybrid fuelled vehicle can enhance the image of a vendor's brand. While it is impossible for fuel companies to deliver alternatives to benzene, having a hydrogen or electric version of a particular model is beneficial.

Since the oil crisis of the 1970s, most automobile vendors have developed an alternatively fuelled version of their most popular models and used this as part of their marketing campaigns. When Daimler Benz launched the 400 series compact automobile in Europe, it demonstrated a fuel cell version of the model and explained to the consumer that, at some point in the future, the conventional benzene or diesel powered unit could be exchanged for one that ran on an alternative fuel. The consumer was being offered a product that was 'fuel cell ready' just as personal computers launched in the run up to the release of a new operating system have been sold as 'Windows XP ready' or 'Vista ready'.

However, the incumbent automobile vendor's business model will come under threat when alternative energy providers start supplying fuels for next generation vehicles. While government agencies discourage motorists from driving their customised high performance vehicles at 250 mph – and actually build infrastructure that makes it difficult to do so – they are actively encouraging motorists to use alternative fuelled automobiles. In addition, the incumbent manufacturer will find it increasingly difficult to co-opt the disruptive alternatively fuelled automobile model without devaluing other models, sold under the same brand name, that run on benzene or diesel.

In theory, it should be possible for the incumbent manufacturers to sell a new model to every customer that has bought a benzene powered model during the last decade. In practice, they are unlikely to be able to adapt fast enough to take advantage of this opportunity.

In theory, it should be possible for the incumbent to use the arrival of new fuels to sell a new vehicle to every customer that has bought a benzene powered model during the last decade. In practice, as they are saddled with legacy manufacturing facilities, healthcare costs and supply chains, they will find it difficult to co-opt the models being used by NextGen automobile manufacturers.

The electric vehicle poses an immediate and unique challenge to the incumbent automobile manufacturer as it uses fuel that is already delivered to householders and businesses in a clean and easy-to-use format. The electricity supply industry will actively promote the electric vehicle and may disrupt the supply chains of incumbent automobile manufacturers by marketing small electric vehicles in the same way as they promote domestic appliances. To facilitate this they may enter into alliances with NextGen vehicle manufacturers.

The electricity supply industry will actively promote the electric vehicle and may disrupt the supply chains of incumbent automobile manufacturers by marketing small electric vehicles as domestic appliances.

4.2 The Impact Of The New Use Model

Incumbent US automobile manufacturers have been slow to develop small automobiles of the type that are typically used as second vehicles in urban areas. The market for these models is now dominated by European and Far Eastern companies.

If the market for electric vehicles continues to expand and consumers start using them as second vehicles or for short commutes, the incumbents could find they are permanently locked out of the small automobile sector. However, the small vehicle market is also vulnerable to changes in the automobile use model – particularly the adoption of the social use model. Car clubs could steer many consumers away from vehicle ownership and cause parts of the second vehicle market to resemble the corporate fleet market. If they achieve scale, car clubs could start to negotiate special deals with manufacturers, putting pressure on margins.

If the electric automobile market continues to expand and consumers start to use them as second vehicles or for short commutes, the incumbents could find they are permanently locked out of the small automobile sector.

Companies that are deploying social automobile use models will also pressure manufacturers to produce smarter vehicles to support applications such as dial a ride and real time vehicle location and perhaps even the networking of groups of vehicles.

5 The Oil Producer And The Automobile Market

For the next two decades the personal transport sector will remain one of the oil industry's most important markets. At present, fossil fuels are needed to produce electricity and hydrogen, so even the emergence of a New Fuel model will only have a small impact on the oil industry. Oil companies may even find that, for a few years, their margins increase as they save money on refining and distribution.

Even the emergence of a New Fuel model will, initially, only have a small impact on the oil industry as, at present, fossil fuels are needed to produce both electricity and hydrogen.

However, a steadily growing market for electric vehicles could have unforeseen consequences for oil companies. Automobile designers are employing lighter materials to maximise the range of electric vehicles. These materials will also be used in the construction of new benzene and diesel power vehicles – reducing fuel consumption and increasing the competitiveness of conventionally powered vehicles. A reduction in oil consumption within the automobile sector would also go some way to postponing peak oil and lessening government concerns regarding energy security and emission levels.

5.1 The Impact Of The New Fuel Model

In the medium term the oil producer will find the nuclear industry attempting to capture a larger proportion of the electrical energy market. Nuclear power advocates will also argue that electricity generated in a nuclear power station is the most practical way of generating hydrogen without increasing carbon emissions.

The tipping point for the oil industry will occur when easily exploited sources of oil are exhausted and producers attempt to tap reserves of tar sands and oil shale. These reserves of unconventional fossil fuel are expensive to exploit and require a new generation of extraction and processing technology to convert them into a suitable feedstock for refineries. The extraction techniques currently in use are energy intensive and create significant environmental damage. Unless a more efficient and cleaner way to extract unconventional oil reserves can be found it is likely governments will give in to pressure from environmental groups and limit development of fields.

The tipping point for the oil industry will occur when easily exploited sources of oil are exhausted and producers attempt to tap reserves of tar sands and oil shale.

As this tipping point approaches, governments throughout the industrial world will provide additional funding for research into a wide range of alternative fuels. Oil companies, such as Chevron, already have research programmes in place and are investigating ways to replace conventional fuels with hydrogen and assess the feasibility of distributing hydrogen via filling station networks.

The use of hydrogen as an energy carrier could prove particularly disruptive for the oil industry, as in some cases it could be generated close to the point where it is consumed. This would make much of the oil industry's downstream infrastructure – such as refineries and filling stations – redundant. In addition, the increasing use of renewable sources of energy, such as wind, solar and hydro, to power electric vehicles is a net and irretrievable loss for the oil producer. While companies such as BP are attempting to position themselves within this market, the success of their strategy depends on a steady migration of the automobile from a conventional to a NextGen fuel model. Should the market reach a tipping point when BP attempts to exploit unconventional reserves of oil, the company could find it difficult to support an expansion of its renewable energy division with shrinking revenues from its legacy operations.

While companies such as BP are attempting to position themselves within this market, the success of their strategy depends on a steady migration of the automobile from a conventional to a NextGen fuel model.

5.2 The Impact Of The New Use Model

A change in the automobile use model would have an immediate impact on the oil producer. While the congestion charging system in London, UK has only reduced traffic entering the centre of the city by 8%, this is a decline in road use at a time when, in other parts of the country, the number of vehicles using roads is increasing due to economic growth. Additionally the stated aim of a number of road charging and congestion charging schemes is to structure fees according to the vehicle's emissions, with no charges at all for electric and hydrogen powered vehicles. This will discourage the use – and eventually the purchase – of large vehicles such as SUVs. It will also motivate some consumers to experiment with electric motorcycles and automobiles.

A change in the automobile use model would have an immediate impact on the oil producer. While congestion charging in London, UK only reduced traffic by 8%, it did this against a rising trend and during a period of economic growth.

Car clubs and lift-sharing schemes will remove at least one car from the consumer's driveway and reduce the amount of casual or impulsive journeys the consumer makes. While new consumer behaviour, such as shopping online, may bring more commercial vehicles onto the roads, this will not compensate for the fuel consumed during individual journeys the consumer makes to stores.

Technology that makes public service vehicles smarter will also reduce the fuel consumed by mass transit systems, and, if these smarter systems become efficient enough to replace individual automobile journeys, the amount of fuel used per passenger mile will fall markedly.

For the oil industry the worst-case scenario is the combined impact of the New Fuel and New Use models reducing margins at a time when producers and refiners are attempting to attract the investment required to diversify or develop a new business model based on alternative fuels.

For the oil industry the worst-case scenario is a combination of the New Fuel and New Use models.

6 The Motorist And The Automobile Market

The motorist has become increasingly dependent on the automobile in two ways. Firstly, their vehicle is an essential and relatively flexible means of transporting themselves between their home and their place of work or local store. Many people in the developed world have adjusted their lifestyle to suit an infrastructure that has been built around the model of ubiquitous automobile ownership and use, and now have few alternatives. Secondly the automobile has also become a symbol of the owner's wealth and status. For large corporations, especially those with relatively flat salary structures, the automobile has become a secondary form of remuneration.

Many people in the developed world have adjusted their lifestyle to suit an infrastructure that has been built around the model of ubiquitous automobile ownership and use, and now have few alternatives.

Companies benefit by rewarding employees with the use of an automobile. Allowing them to use a fixed asset, which remains on the balance sheet for three years, is preferable to increasing the wage bill – which appears as a cost in the profit-and-loss statement. The employee also perceives the use of a vehicle, which in many cases they would not be able to afford to buy and run privately, as a benefit – this despite the fact that company car ownership depresses salary levels and impacts on pension entitlements. The policy of rewarding an employee who has been promoted by allocating them a more expensive automobile has enabled the motor manufacturer to create a rigidly hierarchical market for models which has gradually been extended into the domestic market.

Falling somewhere in between the practical and emotional elements of ownership and use, which satisfy the motorist's secondary and tertiary needs, is the concept of vehicle ownership as an expression of freedom of the individual. It is a tribute to the marketing campaigns of the automobile manufacture and oil companies that the motorist is willing to bear the costs of what has become an essential mode of transport. Owners of private automobiles expend a significant proportion of their income financing the purchase of the vehicle, refuelling it, maintaining it and paying taxes, tolls and parking fees when they use it. Most drivers are unable to reproduce the open road scenarios presented to them in advertisements that encouraged them to purchase a particular vehicle. Despite this they regard automobile ownership itself as a liberating experience.

It is a tribute to the marketing campaigns of the automobile manufacture and oil companies that the motorist is willing to bear the costs of what has become an essential mode of transport.

6.1 The Impact Of The New Fuel Model

At a practical level, the gradual introduction of biofuels is largely transparent to the motorist as it is delivered through the same refuelling infrastructure as benzene or diesel and requires only a minimal change in behaviour. Biofuels are being marketed as an environmentally friendly fuel and appeal to those drivers who are concerned over the link between automobile use and climate change. Decades of promotion of the automobile as a fashion accessory have made the motorist susceptible to any new trend in the market. This, and concerns over the price and security of supply of crude oil, has been a key factor in the popularity of the Toyota Prius.

Biofuels are being marketed as an environmentally friendly fuel and attract drivers who are concerned over the link between automobile use and climate change.

Electric powered vehicles offer the motorist a clean and simple way of refuelling a vehicle. The owner's perception of the electric vehicle is that it can be powered with clean energy from a secure source.

If, at the time of purchase, the potential vehicle owner believes that crude oil supplies will be disrupted within the next five years they are more likely to opt for an electric powered vehicle that they can refuel at home. However, if oil prices are falling, the potential purchaser is unlikely to turn their back on the extra power and performance a benzene or diesel powered vehicle offers.

Until a safe and low-cost means of producing and distributing hydrogen exists, few motorists will buy hydrogen-powered vehicles or invest in home refuelling stations. If, however, hydrogen becomes a feasible energy source for the automobile, advocates of the hydrogen economy could use the motorist's perception of the automobile as a symbol of freedom and independence to their advantage. On previous occasions when oil prices rose sharply, there was significant animosity on the part of motorists towards oil producers. Assuming that the use of hydrogen as an energy carrier will be introduced at a time when benzene and diesel are both in short supply and expensive, advocates of the hydrogen economy could find many new recruits amongst the ranks of disgruntled motorists.

If hydrogen does become a feasible energy source for the automobile, the advocates of the hydrogen economy could use the motorist's perception of the automobile as symbol of freedom and independence to their advantage.

6.2 The Impact Of The New Use Model

Modifying, or reducing, automobile use is proving difficult due to both the lack of alternatives and the motorists' emotional attachment to their vehicles. Government efforts in this area are often confrontational, with vocal objections from motorists and motoring organisations to initiatives such as congestion and road charging. Governments face the problem of attempting to change the motorist's established attitudes to the automobile at a time when the marketing departments of automobile manufacturers are spending millions of dollars to reinforce those same attitudes.

Governments face the problem of attempting to change the motorist's established attitudes to the automobile at a time when manufacturers are spending millions of dollars on marketing to reinforce those same attitudes.

There is, however, a small group of motorists who are experimenting with the New Use models. Most of the activity is focused on car clubs and lift-sharing services – which provide a practical transportation solution and may also fulfil one of the motorist's tertiary needs. Instead of displaying wealth and status via the ownership and possession of an automobile, the consumer achieves a sense of belonging through membership of a large and dynamic group of like-minded people. Satisfying such tertiary needs has proved a key factor in driving the rapid expansion of online services such as eBay and MySpace. Membership of a car club also provides reassurance for consumers who feel that by forgoing automobile ownership their freedom to travel is restricted.

The majority of early adopters of social transport services will not be drawn from the pool of existing automobile owners. Most will be heavy online services users who will shop and work online, live in an urban area, do not own a vehicle and whose propensity towards automobile ownership was already low. However, if car clubs and lift-share schemes achieve scale then existing automobile owners will be attracted by the benefits of social transport, with many families opting for membership as an alternative to owning a second vehicle.

The majority of early adopters of social transport services will not be drawn from the pool of existing automobile owners.

The next generation of aging baby boomers will be familiar with the benefits of online services. When they begin to find driving too difficult and the fixed cost of automobile ownership too high, they are likely to turn to lift-sharing services. The success of the social use model, however, will be highly dependent on the development of smart transport systems and of transport infrastructure less dependent on automobile ownership.

The success of the social use model will be highly dependent on the development of smart transport systems and of transport infrastructure less dependent on automobile ownership.

7 Markets And Opportunities

The structure of the automobile market will change significantly over the next two decades. This change will be driven by the increase in the cost of crude and government initiatives to reduce the automobile's contribution to congestion in urban areas and CO_2 levels.

These changes will provide a range of opportunities for key players in the automotive manufacturing, transport and energy sectors.

7.1 Opportunities Within The 'As Is' Model

7.1.1 Biofuels suppliers are already benefiting from government subsidies and the growing trend for incumbent fuel providers to mix biofuels with conventional diesel and benzene and then market the resulting fuel as a 'green energy source'.

Opportunities exist within the 'As Is' model for biofuel suppliers and companies with technology that can be used to reduce benzene and diesel consumption and monitor vehicle emissions.

7.1.2 Companies with technologies that lower the fuel consumption of conventionally powered automobiles will find a growing market for their products from manufacturers keen to reduce emissions, and oil companies seeking ways to maximise diminishing oil supplies.

7.1.3 There will be a growing market for technology that provides continual monitoring of vehicle emissions as opposed to checking a vehicle as it leaves the factory or during a roadside check.

7.2 Opportunities Within The New Fuel Model

7.2.1 Electricity providers could exploit the market for small electric vehicles. They will already be capturing part of the automotive energy market at the expense of benzene and diesel retailers and may also capture market share from incumbent automobile manufacturers by selling the vehicles made by NextGen automobile manufacturers through the same channels they use to supply household appliances.

Opportunities exist within the New Fuel model for electricity generators, NextGen, vehicle manufacturers and companies with technology that can be used to produce, transport and dispense hydrogen.

7.2.2 Hydrogen economy advocates could use the support of automobile user and lobby groups to increase interest in distributed energy systems and hydrogen as an alternative to fossil fuels.

7.2.3 Hydrogen generation, storage and distribution technology vendors will benefit from any increased use of hydrogen powered automobiles. In the short term they will attract investment from both the private and public sector and earn revenue from trial installations of automobile refuelling systems.

7.2.4 NextGen vehicle manufacturers may exploit the fact that incumbent players cannot easily co-opt the New Fuel model without cannibalising the revenue generated by conventionally fuelled vehicles within their product portfolio.

7.3 Opportunities Within The New Use Model

7.3.1 As more congestion and road use charging systems are deployed, and existing schemes are expanded, there will be a growing demand for a range of vehicle identification and tracking systems along with advanced software that reduces the amount of man-hours required to support such systems.

Opportunities exist within the New Use model for online car and journey sharing services and companies with technology that can monitor and charge for vehicle use.

7.3.2 There is a potential market for smart transport systems ranging from vehicle tracking systems to let passengers know how long they have to wait for the next bus to networked car and minibus systems that provide public and shared transport journeys with the flexibility and granularity that compares to that of a private car journey.

7.3.3 An aging population and increased use of online services will see a growing popularity of car clubs and lift-sharing schemes, some of which will be small scale and non-profit making while others will be deployed nationwide as commercial enterprises.

8 Conclusions

8.1 Three models, 'As Is', 'New Fuel' and 'New Use', will define the shape of the automotive market during the next two decades. The 'As Is' model sees the industry remaining much as it is today: operating within the confines of diminishing oil supplies and increasing regulation of emissions. The New Fuel model is based on an increasing use of hydrogen and electricity to power automobiles. The New Use model sees automobiles used less or in a more efficient manner – for example within shared ownership and lift-sharing schemes.

Three models, 'As Is', 'New Fuel' and 'New Use', will determine the shape of the automotive market during the next two decades.

8.2 Biofuels can be regarded as a component within the 'As Is' rather than the New Fuel model, as there are limits to the amount of fuels that can be produced from crops. The key use of biofuels will be as a supplement to benzene or diesel that postpones peak oil and extends the viability of the 'As Is' model.

Biofuels can be regarded as a component within the 'As Is' rather than the New Fuel model, as there are limits to the amount of fuels that can be produced.

8.3 Most government efforts to limit car use are confrontational and meet significant resistance from car owners, who have an emotional attachment to their vehicles, and motor industry lobby groups. The motor industry's promotion of car ownership, and the absence of practical alternatives to the private car for most journeys, lessens the impact of government initiatives. Despite this, there are a number of grassroot initiatives such as lift sharing and car clubs – built on an online, social network model – that are increasing in popularity.

Even though the motor industry's promotion of car ownership, and the absence of practical alternatives to the private car for most journeys, lessens the impact of government initiatives, social use of vehicles will increase.

8.4 Governments may wish to address a number of automobile use related issues in parallel, for example the number of elderly people who are no longer able to drive, concerns over emissions and the erosion of the quality of life in urban areas. The government could then promote the New Use model as a solution with tangible benefits for the consumer.

Governments may wish to address a number of issues relating to automobile use in parallel.

8.5 The New Fuel model will disrupt the business models of both the incumbent automobile manufacturer and the oil producer and will be used as a route into the market by NextGen vehicles manufacturers. Co-opting the New Fuel model without cannibalising revenue from their existing product lines will prove a challenge for incumbents.

Co-opting the New Fuel model without cannibalising revenue from their existing product lines will prove a challenge for incumbents.

8.6 It will be at least a decade before hydrogen can be used as an alternative to diesel or benzene. However, if oil supplies are disrupted, some motorists might be attracted to the New Fuel model promoted by advocates of the hydrogen economy, as the concept of distributed and localised production of fuel may find appeal amongst people who see the automobile as a symbol of individual freedom.

During a future disruption in oil supplies, certain aspects of the hydrogen economy might prove attractive to some motorists.

8.7 Electricity generators will use the electric car as a tool for expanding their share of the energy market. This, and wide scale use of electric vehicles within urban areas combined with lift-sharing and car club schemes, could impact on the small vehicle divisions of incumbent automobile manufacturers.

Electricity generators will use the electric car as a tool for expanding their share of the energy market.

8.8 To protect their small vehicle market, incumbent automobile manufacturers should consider co-opting the New Use model and develop smart vehicles that easily integrate with the online systems used by car clubs and lift-sharing schemes. Public transport operators should also use smart vehicles to increase the granularity and flexibility of mass transit systems.

Incumbents should co-opt the New Use model and develop smart vehicles that easily integrate with the online systems.

8.9 The New Use model will impact on the car hire sector and could result in parts of the private vehicle market operating along the same lines as today's corporate vehicle fleets. This would see an erosion of the automobile manufacturer's margins on small vehicles and significant loss of business for car hire companies. Both parties should consider protecting their margins by marketing private transport solutions rather than individual vehicles or, in the case of car hire companies, individual journeys.

The New Use model will impact on the car hire sector and could result in parts of the private vehicle market operating along the same lines as today's corporate fleet.

9 Vendors

9.1 Chevron

Chevron Corporation is one of the largest energy companies in the world and is engaged in every aspect of the oil and natural gas industry including exploration, production, refining, marketing, transportation, chemicals manufacturing and sales, and power generation. It has its headquarters in California, USA and conducts business in approximately 180 countries.

Chevron Technology Ventures is the subsidiary of Chevron that identifies, develops, invests in and commercialises new energy systems and emerging technologies such as hydrogen-related technologies, advanced energy storage technologies, renewables and nanomaterials.

As part of California's Hydrogen Highway Network programme, Chevron is providing Humboldt State University with $350,000 of funding to build an on-site hydrogen generation fuelling station.

Chevron also has an agreement with Ford Motor Company to construct a hydrogen energy station to fuel Ford's hydrogen internal combustion engine shuttles for use at Orlando International Airport. It is also collaborating in Alameda-Contra Costa Transit District's (AC Transit) HyRoad demonstration programme, providing hydrogen from the energy station for its fleet of three zero-emission fuel cell buses powered by UTC Power fuel cell systems and ISE hybrid-electric drive systems, and up to ten zero-emission Hyundai and Kia fuel cell cars, also powered by UTC Power fuel cells.

Chevron Technology Ventures signed a Cooperative Research and Development Agreement (CRADA) with the US Army's Tank and Automotive Research, Development and Engineering Centre (TARDEC) in September 2005 to further hydrogen fuelling technologies. Chevron Technology Ventures and TARDEC will each fund their own contribution to this collaborative effort.

Chevron at a Glance

Chevron Technology Ventures is the subsidiary of Chevron that identifies, develops, invests in and commercialises new energy systems and emerging technologies such as hydrogen-related technologies, advanced energy storage technologies, renewables and nanomaterials.

www.chevron.com

Analysis

It is encouraging to see oil companies finally embracing an alternative fuel future. Collaboration with industry, academia, and government agencies will see the problems with delivery, storage, availability, infrastructure, and distribution being solved. Oil companies are now involved in many projects demonstrating fuel cell cars and buses, and hydrogen fuelling stations. Although the developments so far have been positive, the financial commitment has been very small indeed for companies that earn hundreds of billions of dollars in revenue. Evidence of this lies in the fact that the technology behind fuelling stations is developed and supplied by other companies. Perhaps this is not so surprising given that hydrogen can be produced from many sources including methane, biomass, coal, and water, and by several chemical companies. Entering into the hydrogen production market may become inevitable for oil companies if the demand for hydrogen fuelled vehicles increases through targeted government policies leading to the hydrogen supply market requiring more participants in order to meet demand.

9.2 General Motors

General Motors (GM) Corporation, founded in 1908 and headquartered in Detroit, USA, is one of the world's largest car makers, with manufacturing facilities in 33 countries. It is well known for its brands: Buick, Cadillac, Chevrolet, GMC, GM Daewoo, Holden, HUMMER, Opel, Pontiac, Saab, Saturn and Vauxhall. GM is the majority shareholder in GM Daewoo Auto & Technology Company of South Korea, and has product, advanced technology and manufacturing collaborations with most of the large car manufacturers in the world. GM operates a finance company, GMAC Financial Services, which offers automotive, residential and commercial financing and insurance. GM's OnStar subsidiary is a vehicle safety, security and information service provider.

GM has been working on alternative technology vehicles for some time. Its record-setting Sunraycer, a solar-powered electric car produced in collaboration with AeroVironment, and Hughes Aircraft, won the first World Solar Challenge in Australia in 1987. It generated 1.5 kW at high noon and reached a top speed of 109 kph. The Sunraycer largely inspired the EV1, a plug-in electric car leased to customers between 1996 and 2000. GM has built several prototypes of the EV1, demonstrating the diesel-electric parallel hybrid, gas turbine-electric series hybrid, fuel-cell-electric version, and compressed natural gas internal combustion engine version at the 1998 Detroit Auto Show.

GM conceived the E-Flex (the E stands for "electric") drive system concept, a template for a vehicle that can be driven exclusively by electricity, with the additional capability of being driven by other propulsion systems, all fitting into a common chassis. The vehicle could be configured to generate electricity from petrol, ethanol, biodiesel, or hydrogen to meet the needs and infrastructure of a given market. GM unveiled the Concept Chevrolet Volt saloon in January 2007. It is the first car developed along the lines of the E-Flex system, and can be configured to run on electricity, petrol, E85 (85% ethanol and 15% diesel), or biodiesel.

General Motors at a Glance

The company was formed in 1908 and is still a dominant player in the US automobile market. It has recently returned to the electric vehicle market after abandoning an earlier attempt in 2000.

www.gm.com

Analysis

Like Chrysler and Ford, GM has a product range dominated by large vehicles with high fuel consumptions. These vehicles are declining in popularity due to the recent increase in oil prices. Also having some impact on the sales of large vehicles is the negative marketing of SUVs by the media and environmental pressure groups. Toyota, a relatively new entrant into the US automobile market, is disrupting the business models of incumbent players with its range of small models and a marketing campaign focused on a hybrid vehicle. In the longer term, however, new entrants into the automobile market, with a purely alternative energy play, represent a greater threat to GM than Toyota as they will be able to introduce new models without cannibalising the revenue of their existing product lines. This, in part, is what has motivated GM to revive efforts to introduce an electric car – a project that was put on hold when it scrapped its EV1 vehicle due to low demand and lack of financial viability.

GM is, and is likely to remain for the foreseeable future, a major player in the global automobile market. It could easily adopt a 'wait and see' approach to the alternative fuel model while using the Chevrolet Volt to rebrand itself as a NextGen automobile manufacturer. GM also has the financial muscle to purchase a successful NextGen vehicle manufacturer – although the track record of incumbents who attempt to co-opt the business models of new entrants into established markets is not good.

9.3 BMW

BMW AG, an independent German company, has had a long history, starting as an aircraft engine manufacturer in the early part of the last century and moving on to railway brakes, motorcycle engines, motorcycles and cars. It is well known for its BMW, MINI and Rolls-Royce brands of cars.

Propelled by the European Automobile Manufacturers Association's commitment in 1998 to reducing carbon dioxide emissions of all newly registered European cars to an average of 140 g/km of CO_2 by 2008 (equivalent to a reduction in CO_2 emissions by 25% relative to 1995 levels), the BMW Group joined forces with Aral, BVG, DaimlerChrysler, Ford, GHW, Linde, Opel and MAN in June 2002 to form the CleanEnergy Partnership (CEP) to promote hydrogen technology in Germany. This led to BMW announcing in September 2006 the introduction of the hydrogen-powered 7 – the first hydrogen-drive luxury performance car for everyday use.

To date, BMW is the only major car maker to bring a car with a hydrogen combustion engine beyond the prototype stage. BMW is planning to loan or sell 100 of the hydrogen models to high profile individuals in the United States, Europe and Asia in March 2007, and if they become popular will go into full-scale production.

BMW's competitors in the hydrogen fuelled vehicles sector include General Motors with its Chevrolet Sequel fuel-cell cross-over SUV which can go 483 km before refuelling, the Hydrogen Car Company with its internal combustion engine vehicles, and Ford with its model U concept vehicle also with an internal combustion engine.

BMW at a Glance

The company is a German based manufacturer of prestige high performance automobiles. It has recently developed a hydrogen powered version of its top-of-the-range 7 series model.

www.bmw.com

Analysis

In order for large scale introduction of hydrogen as a fuel to succeed, tank-filling systems for liquid hydrogen and pressurised gaseous hydrogen that are as quick, easy to use, and that offer at least the same level of safety as the current petrol and diesel filling system need to be in place. BMW is developing one such system in a joint venture with Magna Steyr, and a prototype has been operating at Munich Airport for over five years. With no more than five hydrogen fuelling stations in the world supporting BMW's technology, it would cost $29.4bn to introduce 2,000 hydrogen filling stations in Germany alone, and investment would have to rise to about $263bn to replace the existing network of 16,000 filling stations. Safety issues as regards parking such cars in garages over long periods of time also need to be addressed.

German automobile companies dominate the prestige vehicle market, and while the models they produce attract a premium due to their reputation for quality and performance they are vulnerable to any major shift in consumers' attitudes regarding the impact of their own driving habits on the environment. BMW's hydrogen initiative both provides the company with experience within what could become a New Fuel Model and gives the company's customer the impression – genuine or otherwise – that the impact they are having on the environment by driving a conventional BMW 7 series automobile is temporary and will end when the hydrogen-powered model becomes available.

9.4 Lysanda

Lysanda is a small vehicle engineering consultancy based in the UK, that has developed the Eco-Log (previously Eco-Box), a simulation based monitoring tool that calculates a vehicle's performance and gas emissions (hydrocarbons, nitrogen oxides, carbon monoxide, carbon dioxide and particulate matter) in real time in its everyday use. Eco-Log is aimed at operators of commercial and public service vehicles, and car fleets who, provided with data from the tool, would be able to see how their fleets are being driven and maintained and implement strategies to reduce their operating costs, and demonstrate compliance with pollution prevention laws.

Unlike manual tailpipe systems, Eco-Log is on-board mounted and makes its calculations based on manufacturer-supplied data about a particular vehicle model, and data obtained about the engine from the vehicle's on-board diagnostic system such as load, engine speed, throttle angle, engine temperature and (for diesels) injector profile. The results highlight excessive use of speed, revs, brakes and engine tick-over. The data is transmitted at intervals back to the fleet management centre using GPRS as the communications interface, and can be viewed by the driver on a screen.

Lysanda hopes Eco-Log will help reduce carbon dioxide emissions by 450 kg per vehicle per year and save operators between $1,000 and $1,500 per vehicle per year through appropriate maintenance and driver training. Other potential benefits could be the ability of operators to participate in carbon trading, and to avoid paying penalties for entering low emission zones by deploying vehicles with higher environmental performance in those zones. Regional and national governments could also use this technology to levy emissions based car tax by mandating the installation of this device in vehicles.

Lysanda is now seeking funding to take Eco-Log to production. It hopes to earn its revenue by selling each device to after-fit installers for $292, and to OEMs at $97 per unit at low volume production and $10 at high volumes, and leasing each at $2–4 per vehicle per day.

Lydanda at a Glance

This small UK based engineering consultancy has developed an emission monitoring system that measures a vehicle's compliance with emissions standards.

www.lysanda.com

Analysis

Eco-Log has brought a product to the market at an opportune time, as legislation to reduce traffic-generated pollution such as congestion charging, low emission zones, and dedicated lanes for alternative fuel and high occupancy vehicles is on the increase. Used in combination with remote-sensing vehicle emission monitoring systems (such as the Accuscan 4600 marketed by Enviro Technology Services in Gloucestershire, UK and Environmental System Products of Connecticut, USA), air quality statistics may be set to fall over the coming years, especially in the most polluted cities.

The company is however tied to the 'As Is' model of automobile use as, if alternative fuel models were introduced, the Eco-Log product would have little relevance in a market dominated by hydrogen and electric powered vehicles. However, this is some way off and, as government transport planners and municipal authorities introduce automobile use models that employ charging structures tied to a vehicle's emissions, there should be a growing market for Lysanda's products and associated services.

9.5 Transport For London (TfL)

Transport for London (TfL) is a municipal agency which came into being in 2000 and is responsible for most aspects of the transport system throughout Greater London. The organisation has three main directorates – London Underground (responsible for running the underground rail network), London Rail (responsible for coordinating the operators that provide National Rail services within London) and Surface Transport (responsible for buses, river services, London's strategic road network, congestion charging, trams and private hire vehicles among others).

In a measure to improve traffic and environmental conditions in London, the London Congestion Charge was imposed on the city in February 2003. This scheme imposes a daily charge on the registered keeper of a vehicle that enters or moves around within the congestion charge zone between 7 am and 6.30 pm Monday to Friday except on public holidays and between Christmas day and New Year's day. Currently, alternative fuel vehicles (i.e. electric vehicles, those that are powered by liquefied natural gas, and hybrid vehicles) and two-wheeled vehicles are exempt from the scheme.

The present boundary of the zone includes the City of London (the city's financial district) and the West End (the city's primary commercial and entertainment centre). This zone was extended to include west London on 19 February 2007, when the period of operation was also shortened to 7 am to 6 pm.

The London congestion charge brought a 30% reduction in traffic (non-exempt vehicles) in the first six months of operation. This figure has now stabilised at an 8% reduction. Approximately 50% of the drop in vehicle journeys is attributed to people transferring to public transport, 20–30% to journeys avoiding the zone, and the remainder to car sharing, reduced number of journeys, more travelling outside the hours of operation, and increased use of motorbikes and cycles.

Other cities with congestion charging zones include Oslo, Stockholm, Bergen, Trondheim and Singapore.

TfL at a Glance

Transport for London is one of the first municipal agencies in the world to deploy a large-scale road congestion charging scheme and is being closely watched by city authorities around the world that are seeking ways to reduce the impact of automobile use on business efficiency and the quality of life within urban areas.

www.tfl.gov.uk

www.iess.co.uk

Analysis

Despite an overall long term fall in congestion of only 8%, this reduction was achieved at a time when economic growth has increased the traffic on all roads in the UK. The new proposals are likely to exclude more cars from the city as drivers become increasingly unwilling or unable to pay the charges. In countries where fuel taxes are already high, such as the UK, there will be considerable resistance to a nationwide deployment of any form of automobile use model based on charging. Given the likelihood of more people transferring to public transportation, the capacity, availability, and quality of service of public transportation also needs to be improved in line with the anticipated increase in demand. This in turn implies the need for more investment in the public transport network. There is also the possibility that more people will opt to work from home more often in order to avoid the new charges. It remains to be seen whether this would be detrimental to businesses in certain parts of the country, and itself have an adverse impact on the environment, as certain types of businesses relocate offices to rural areas.

9.6 CityCarClub

CityCarClub, founded in 2000 and based in Bristol, is the second largest commercial car club operator in the UK. It operates in eleven cities around the UK including London, Edinburgh, Reading and Portsmouth, has 11,000 members and a fleet of 175 cars. Membership costs and drive-away charges cover road tax, Ministry of Transport (MOT) certification, insurance, value added tax (VAT), maintenance and cleaning.

Its cars are parked in reserved parking bays close to homes and workplaces. Membership of the club provides a driver with a smart card which is swiped across a windscreen-mounted reader to unlock the doors. On entering the car, the driver would enter a PIN number into the car's computer terminal, and subsequently drive away.

The membership structure is based on three categories: Gold – for regular users who require a car for more than eight hours a month; Silver – for low-usage users who want a low insurance excess; and Bronze – for low-usage users who pay less in charges than for Silver membership but have to pay more in insurance excess. Car hire incurs hourly, daily or monthly rates, and a car can be booked online or by phone up to an hour before it is needed.

Other car clubs run along more or less the same lines. Streetcar, the largest car club operator, is based in London and boasts 10,000+ members, and 220+ cars in 150 locations in three UK cities: London, Brighton and Southampton. Each car comes with a petrol card which drivers use to buy petrol, and there is no membership fee. The third largest supplier, WhizzGo, operates in seven cities and has 2,000 members and 70 cars in its fleet. WhizzGo is different from the others in that its cars run on liquid gas and thus its members are exempt from paying the congestion charge. There are a dozen or so smaller operators.

CityCarClub at a Glance

Founded in 2000, the club is the second largest shared automobile ownership organisation in the UK, with 11,000 members and 175 vehicles.

www.citycarclub.co.uk

Analysis

Car clubs provide a timeshare for vehicles, thereby offering an alternative to car ownership for individuals and businesses, and alleviating the pressure on parking spaces in cities. It is estimated that each club car replaces the need for five to eight privately owned vehicles. Car club members tend to sell their cars or second cars when they join a car club, substituting public travel, walking and cycling as part of their lifestyle. In the UK, research has found that former car owners increase their use of non-car transport modes by 40% after joining a car club. Two-thirds of those who owned a car before joining saw their mileage fall by an average of around 25%. A University of Berkeley research project showed car club users in San Francisco reduced overall car travel by 47% in favour of public transport, walking and cycling.

Aiming to reduce car ownership and increase the use of public transport, local authorities are increasingly asking property developers to make space available for car club cars as part of planning approval. Rural areas present more of a challenge, with population densities being lower, thus affecting the accessibility of cars, and may therefore see a different model of car sharing being used. The popularity of car clubs suggests that there is enough of a market for car manufacturers and car hire companies to provide these services as well. Honda experimented with this idea between August 2001 and June 2002, with its Intelligent Community Vehicle System (ICVS) scheme in Singapore using its CIVIC hybrid cars, and its CarLinkII operating in California.

9.7 Honda

Honda Motor Co., Ltd, based in Tokyo, Japan, was founded in 1948. It is the world's largest motorcycle manufacturer and one of the leading car makers. It manufactures and markets other products including small general purpose engines, scooters and specialty sports cars.

Honda introduced the FCX-V4 fuel cell vehicle in September 2001. Since then, Honda has produced a number of generations of the concept FCX fuel cell vehicle which runs entirely on hydrogen with a range of 434 km per tank, with the aim of putting a production version on sale to consumers in 2008.

Honda has also developed a free-standing solar-powered, water electrolysing hydrogen refuelling station, which has been operating on an experimental basis since 2001 at Honda's R&D facilities in California, USA. The solar cells were jointly developed with Stanford University and are made by Honda Engineering. The solar cells generate around 6 kW in a typically sunny Californian week, enough to produce about 3.5 kg of hydrogen a week, which will fill the tank of a single fuel-cell Honda FCX .

Honda has been pioneering the use of hydrogen as a complete solution to individual and household needs for energy and transportation fuel. Since 2004, it has been operating an experimental Home Energy Station (HES) that generates hydrogen from natural gas (piped to the home) for use in fuel cell vehicles while supplying electricity and hot water to the home through fuel cell cogeneration functions. In collaboration with Plug Power Inc., it has built a second generation system, the Home Energy Station III, which unifies the natural gas reformer and pressurising units into one compact component to reduce the overall volume by approximately 50%. The HES III can also be used as a backup power-generating system during power outages by using the hydrogen in its storage tank to power an internal fuel cell. This gives off as much as 5 kW of power in normal and emergency conditions.

Honda at a Glance

The company was founded in 1948 and is the world's largest motorcycle manufacturer. In 2001 it launched the FCX-V4 fuel cell vehicle and since has developed a free-standing solar-powered, water electrolysing hydrogen refuelling station, which operates on an experimental basis.

www.honda.com

Analysis

Honda's Home Energy Station concept could have far reaching implications for the supply of automotive fuel, moving the supply away from oil and chemical companies who would ordinarily supply petrol/diesel and hydrogen respectively to the domain of conventional domestic gas suppliers. Similarly, there would be a move towards the ordinary motorist refilling his/her car at home more often than at a fuel station. This would concentrate all of a household's energy supply in the hands of its selected energy supplier, implying more demand in gas supply per household. If the HES becomes popular, one could see changes in the way residential properties are designed, and a new landscape in towns and cities may emerge.

Elements of the Home Energy Station are in line with the thinking of advocates of distributed energy and the hydrogen economy. If hydrogen does emerge as a viable alternative to fossil fuels, Honda's product could prove highly disruptive to the business models of incumbent energy providers.

9.8 ZAP

ZAP (Zero Air Pollution), formerly ZAP Power Systems, based in California, USA, is a distributor of fuel-efficient alternative fuel vehicles to more than 20 dealerships, with plans to supply through car manufacturers and their dealerships. ZAP entered the electric car business in 2006, when it sold a modified version of the Smart car (a 60 mpg two-seater coupe manufactured by Smart GmbH, based in Germany and 100% owned by DaimlerChrysler AG). It has sold over 300 since then. Also in 2006, it launched the XEBRATM range of four-passenger saloon and two-passenger utility pick-up electric vehicles with a speed of about 64 kph, retailing at under $10,000.

ZAP is planning to launch and distribute the OBVIO in 2008 – a range of micro-cars manufactured by OBVIO of Brazil and designed to run on ethanol, petrol or any combination of the two fuels.

ZAP and Lotus Engineering are currently collaborating to create the high performance electric ZAP-X for the USA market using Lotus's platform and lightweight aluminium body structure design. A new efficient drive and an advanced battery management system are intended to enable a range of up to 563 km between charges, with a rapid ten-minute recharging time. An auxiliary power unit is planned to support longer distance journeys.

ZAP also distributes electric scooters, bicycles, motorcycles, and lithium-based rechargeable batteries for personal electronic equipment. ZAP has delivered over 90,000 vehicles to consumers in more than 75 countries.

ZAP at a Glance

The US based company specialises in designing and building electric vehicles that resemble – in looks and performance – the equivalent benzene and diesel models. To date, it has sold 300 vehicles based on Smart Car. The company is also, in conjunction with Lotus, developing an electric powered sports car.

www.zapworld.com

Analysis

The use of electric automobiles will cause the energy used to power vehicles to be routed through electricity generating companies. While, in the short to medium term (the next 10 to 20 years), oil and gas will be used to generate electricity – and so ultimately power electric automobiles – electric automobiles will disrupt the business models of major oil companies. Value will be taken out of the downstream operations of oil companies and given to electric grid operators. The use of electric cars would also help balance the load of electricity generating companies, resulting in more efficient use of generating capacity if they are used by day and recharged by night. Taking this a step further, an electric vehicle could send excess battery power into the grid at peak times and then recharge during off peak using cheaper power by installing vehicle-to-grid (V2G) technology.

Companies such as ZAP will be helped by municipal authorities that encourage the use of electric vehicles through exemptions from road use charges and vehicle taxes. More could be done in this respect, for example providing electric points in car parking areas to overcome the electric powered vehicle's limited range due to its short battery life.

ZAP work closely with companies such as Lotus and Daimler Benz, demonstrating that they are quite prepared to have their business model co-opted by incumbent automobile manufacturers.

9.9 Toyota

The Prius is the first mass-produced and marketed hybrid automobile. It went on sale in Japan in 1997, and worldwide in 2001. By the end of 2003, nearly 160,000 units had been produced for sale in Japan, Europe and North America. With the 2004 model, the Prius was redesigned as a mid-size hatchback, using a combined 1.5-litre petrol engine and a 50 kW electric motor. The car does 0–100 kph in 10.9 seconds with a top speed 175 kph. Fuel usage is 106 kpg on average and 91 kpg in town. There is no key, just a smart plug that connects to the dashboard. A small lever on the fascia gives drive and reverse.

The Prius doesn't need to be plugged into the grid for recharging, since all energy comes from the internal combustion engine. One reason that the Prius gets such good petrol mileage is that the internal combustion engine is smaller than in most cars its size.

The car starts in electric mode and stays in electric for low to mid-range speeds. The range is only 2 km in this mode. Electric cars have huge amounts of torque, so acceleration is rapid. When the speed increases and when cruising, the petrol engine cuts in so that the petrol and electric motor drive the car together. The generator also recharges the battery using surplus engine power.

Travelling in heavy traffic, the driver presses a button for electric-only drive with zero emissions from the exhaust and zero noise. Under hard acceleration, such as when overtaking, more energy is supplied from the battery to increase power. When braking or slowing down, the electric motor uses regenerative breaking to recover the kinetic energy which would have been lost as heat through friction with the brakes, and stores it as electricity in the sealed nickel-metal hybrid battery.

The Prius has 'drive-by-wire' brakes, throttle and transmission, i.e., these functions are carried out by electronics with no traditional mechanical linkages.

Toyota at a Glance

The company produced the Prius – the world's first mass produced hybrid automobile. Although some of the key advantages of the Prius over conventional automobiles such as lower fuel consumption and emission levels have been eroded, the vehicle has raised Toyota's profile amongst environmentally aware consumers.

www.toyota.com

Analysis

Although the Prius has impressive fuel efficiency statistics, the fact that it is not a plug-in hybrid means that it loses out in not being able to use less carbon-emitting power from gas, nuclear or renewable energy sources. However, at 0.18g/km CO_2 emissions (32% less than from a normal petrol-burning car) and negligible particulate matter, it can be said to be contributing to the drive to reduce noxious emissions.

The value of the Prius to Toyota is that it differentiates a relevantly new entrant into the US automobile market from the incumbents and has attracted consumers who have turned their backs on large vehicles with high fuel consumptions in favour of smaller models that use less fuel and produce less carbon emissions. The presence of the Prius in its range has made Toyota more fashionable – itself an important aspect of marketing automobiles. However, most major automobile companies have also added a next generation model to their range and Toyota could lose its key differentiator. In addition, while Toyota has positioned itself as a NextGen automobile company, a majority of its product range is made up of conventional fossil fuel driven models. If a significant number of true NextGen automobile manufacturers enter the market, Toyota will be forced to refine and expand production of the Prius and run the risk of cannibalising revenue from its conventional models.

9.10 Greenergy Fuels

Greenergy has developed a range of low-carbon fuels called GlobalFuels. These fuels feature a blend of biofuels, such as bio-diesel or bio-ethanol, and mineral fuel. Greenergy supplies high octane (99 Octane) unleaded petrol containing 5% bioethanol; ultra low sulphur petrol and diesel; a blend of 50% standard diesel and 50% biodiesel called GreenergyB50 targeted at fleet users such as hauliers; gasoil (also known as heating oil) for off-road applications; and kerosene. The GlobalDiesel brand is made from 5% biodiesel.

The company sells to a wide range of customers including supermarkets and oil companies for sale to their forecourt customers, bus companies, hauliers and other major fleet users, resellers and distributors, and corporate customers. Greenergy's biodiesel customers include Tesco, Morrisons, Asda, Sainsbury's, Iceland Foods, Conoco-Philips, Arriva, Lafare, Eddie Stobart, the British Airports Authority, the Metropolitan Police and several local authorities and UK Government departments. Greenergy also supply Brazilian sugar-cane ethanol to Tesco.

Greenergy sources its biofuel feedstock from rapeseed (grown by 1,500 UK farmers), used cooking oil and other virgin oils. In 2006, the volume of rapeseed being bought was just over 160,000 tonnes, equivalent to about 10% of the UK rapeseed crop. Its processing plant in Lincolnshire, designed for mixed feedstock, produces 100,000 tonnes of biodiesel per annum, with plans underway to double this capacity, and further plans to open another plant near Liverpool. In the future, some of Greenergy's ethanol will come from a new refinery in Norfolk, UK which is currently being built by British Sugar, DuPont and BP. The new refinery is to use UK sugar beet to provide 55,000 tonnes of ethanol per year. This is likely to increase overall sales, but not displace Brazilian ethanol.

Greenergy at a Glance

Formed in 1992, the UK based subsidiary of Greenergy International Ltd is 25% owned by Cargill, and 25% owned by the retailer Tesco.

Greenergy has developed a range of low-carbon fuels called GlobalFuels. These fuels feature a blend of biofuels, such as bio-diesel or bio-ethanol, and mineral fuel.

www.greenergy.com

Analysis

While using biofuels may be a good alternative to burning fossil fuels while at the same time removing carbon from the atmosphere, the land available in most countries for production of these energy crops is not sufficient to supply the biofuel needs of their societies, and will, for the foreseeable future, be in competition with food crops which will always command the highest priority for countries that have to import food. A key benefit of Greenergy's product is that a high proportion of it is derived from recycled cooking oils.

As there are obvious limits to the global production of biofuels and these are likely to remain, even with the development of second and third generation biofuel crops, Greenergy must be regarded as part of the 'As Is' model of the automobile industry.

Greenergy's success in being able to incorporate oil crop imports into its products while retaining the respect of non-governmental organisations will depend on its ability to engage with its suppliers in implementing and ensuring sustainable agricultural practices that include the provision for increasing biodiversity.

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