



**Knowledgefaber**

## **Alternative Propulsion System**

A Knowledgefaber Study

This study talks about different kinds of alternative propulsion systems for vehicles and their market penetration in different economies mainly BRIC (Brazil, India, China, and Russia) and some comparisons with US. It also lays out the challenges faced by these systems and how the world is reacting to them.

**11/23/2009**

**INTRODUCTION:**

According to a key global study 83% of the world's population is ready to change their consumption habits to make the world a better place to live in! Nations are trying to come up with new ways for conserving the nature. One such inception is the alternative propulsion system which is an effort to fight the global warming.

APS or alternative propulsion system refers to the various techniques being used in the automotive industry to control the carbon emissions. Other benefits include conservation of natural resources, cheaper transportation, better efficiency etc. The major developments have been seen primarily in four sectors: - solar power, bio-fuel, hybrid and fuel cells.

According to the ministry of environment and forest of India, 15-20% of the nation's greenhouse gas (GHG) emissions is contributed by the automobile sector and it is projected to rise upto 25% by 2030 if it goes unchecked. It would not be very different in other BRIC countries as well and that's where it becomes important to study this subject.

**DIFFERENT TYPES OF ALTERNATIVE PROPULSION SYSTEM:****Fuel Cell:**

A fuel cell is an electrochemical cell producing energy from a fuel tank. They have a high efficiency ratio and are used in some countries for transportation purposes for their benefits like being cleaner, more efficient, etc. Fuel-cell technology is looked as promising solution for reducing the carbon dioxide emissions as it generates electricity by combining a fuel - usually hydrogen with oxygen, and the by product is water. Research in this field is on an all time high and many countries are stepping up to reap the benefits.

**Bio-fuels:**

Bio-fuels are liquid fuels derived from plant materials. Bio-fuels provided 1.8% for the world's transport fuel in 2008 and its use is increasing exponentially. They are categorized in three generations – 1<sup>st</sup> (bioalcohols, biodiesel, solidbio-fuel); 2<sup>nd</sup>(biohydrogen,biomethanol,DMF);3<sup>rd</sup> (algae fuel). Helioculture is a new technique developed for harnessing these bio-fuels efficiently.

**Hybrid Vehicle:**

A hybrid vehicle usually has more than two distinct power sources to move the vehicle and primarily includes the hybrid electric vehicles. They use a multiple propulsion system to provide motive power and the power sources may include RESS (Rechargeable energy storage system), wind, liquid nitrogen, human power, etc. Hybrid vehicles have already made their way in the global economies and are being appreciated which is evident from the fact that in 2009, the sale of hybrid cars in US alone was more than 20,000 units.

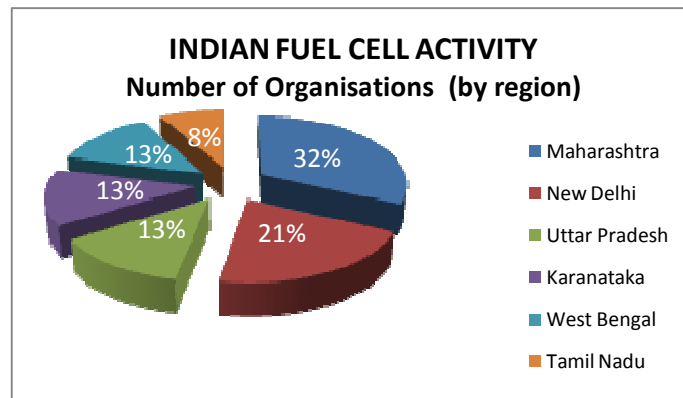
**Solar Power:**

Sun is a vast source of energy and its energy is being tapped for several purposes, one of them being the automotive sector. A solar car is an electric vehicle which has solar panels mounted on top of it to absorb the sun's rays which is then converted as a fuel for running the car. Solar cars have not yet achieved the status of practical form of transportation and are mainly used for recreational purposes such as racing.

**R&D investment by public and private sector:****Fuel Cells:-**

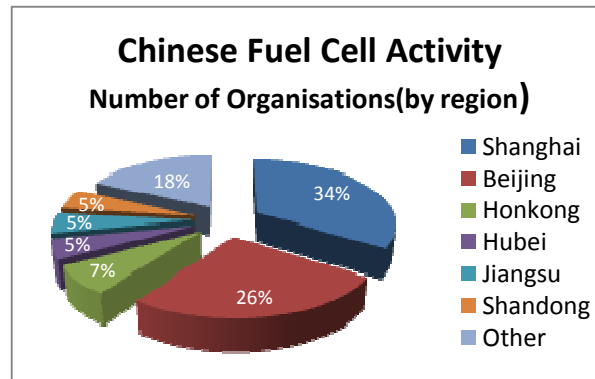
India's investment in the field of fuel and hydrogen cells is around \$2.5 billion. Of the total R&D spend on fuel cells in India 20% comes from private sector, 5% from higher education institutes and the rest 75% is from the government funding.

The top car manufacturers in India like Tata Motors and Mahindra are trying to rev up their fleet with these energy saving green cars. Toyota's hybrid Prius has been globally accepted as an eco-friendly car. Ashok Leyland, Bajaj Auto, Tata Motors, Mahindra & Mahindra and Eicher Motors have decided to join forces to develop hydrogen blended compressed natural gas (HCNG) run vehicles for a cleaner India. Tata Motors have launched a \$6,90,00 project for fuel cell buses. Maruti Suzuki is coming up with a new model of its crossover SX4 which will be driven by fuel cell technology and will be 64.37% more fuel efficient. Reva is investing \$20million globally in the R&D of fuel cell vehicles. As India is one of the fastest growing economies, global majors like Toyota, GM, Mercedes Benz, Hyundai, Ford and Renault are also coming up with their R&D centers in India.



Brazil already has fuel-cell buses running on its roads, a \$16 million project made possible by the joint efforts of Brazil's Ministry of Mines and Energy and EMTU/SP (Sao Paulo Metropolitan Urban Transport Company) and several other entities like AES Electro Paulo, Ballard Power Systems, Petrobras etc. Global car makers like Toyota, Mercedes, Nissan, Renault, Honda, Hyundai and General Motors are all coming up with their efficient fuel cell models in Brazil.

Public and private investments in the R&D of fuel cell technology in China over the next few years are projected to be over \$500 million, with the top priority being transportation sector. Under China's fuel cell roadmap, between 2005 and 2010 more than 100 buses will be tested as demonstration projects in China. More than 1000 fuel cell powered buses will be utilized in regular bus operations between 2008 and 2020. Automotive companies like Toyota, Honda and Volkswagen have already launched their fuel cell vehicles in China and are setting up plants for further research and development and have already invested more than \$15 million.



The Russian government has shown keen interest in developing fuel cells for a cleaner Russia. There have been investments of \$3.5 million for the R&D of fuel cells in the past year. Russia is however taking a different path, while other countries are developing Polymer Electrolyte Fuel Cells, Russia is developing Alkaline Fuel Cell stacks. GM, Toyota, VW, Ford and Renault have either opened their manufacturing units for fuel cell development in Russia or are in the process.

In order to lay the foundation of green economy the Department of Energy (USA) has announced an additional \$41.9 million investment into the fuel cell technology recently. The U.S. government has hydrogen and fuel cell research programs primarily under the Hydrogen, Fuel Cells, and Infrastructure Technologies Program run by the Department of Energy (DOE). The U.S. government's prime focus is on high-risk applied R&D. The administration increased funding in 2003 with a \$1.2 billion program known as the Hydrogen Fuel Initiative. In spite of the Obama administration's reluctance over further research in the field of fuel cells and inclination towards bio-fuel, Toyota and GM have decided to go ahead with their plans. Danbury's Fuel Cell Energy Incorporation has been awarded \$1.5 million from Army Corps of Engineers for their ongoing research on electrochemical hydrogen separator..

**Hybrid cars:-**

India due to its large and growing automobile industry has become the eye candy of automobile giants. Toyota will be soon launching its globally acclaimed hybrid car Prius in India. Reva Motors were the first ones to introduce the hybrid car concept in India and now with a funding of \$20 million they are doing a lot of research in the field of hybrids, but they have not been successful due to their low specs and high pricing. Maruti Suzuki is even revamping its crossover SX4 which is claimed to be 64.37% more fuel efficient. Mahindra & Mahindra are coming with Start-Stop hybrid version of Scorpio. However, the Honda Civic hybrid is the only fully hybrid car available in the Indian market. Tata Motors will be launching a hybrid version of their Indica soon. Delhi based AKSA auto-trade has joined hands with Canadian design company CKE Technologies to develop an indigenous hybrid, Beaver, which is expected to be priced under \$6500. On a whole, the hybrid car market in India is in its budding stage but the developments in this field are showing good promises.

Brazil is a forerunner when it comes to hybrid cars. Brazil alone accounts for more than 50% of the hybrid automobiles in the world. There are around 17 million (as of mid 2009) flexible-fuel vehicles worldwide, out of which Brazil alone has around 8.2 million. Almost all major car manufacturers have their plants in Brazil. General Motors is trying to come up with a new line of low fuel consumption Chevrolet and GM Brazil is investing \$2 billion for the project and the plant's expansion. Fiat has joined hands with two Brazilian utilities, Cemig and Itaipu to develop electric vehicles for Brazil. Brazil has made its stand in the market of hybrid cars and is showing good potential for further developments.

The Chinese government is planning to hike the annual production of hybrid cars to 500,000 in the next two years. The hybrid car market is booming in China. The Chinese government will give \$6,300 in subsidy to buyers of hybrid cars. China's first indigenous hybrid model BYD Auto's F6DM already hit the market in early 2008. GM has chosen China, one of the world's fastest growing vehicle markets, as its key center for developing alternative power sources and is investing \$250 million for a plant in Shanghai. There have been 2500 Priuses (Toyota) sold in China since 2006. Chang'an Ford's Chinese partner is also coming up with its own line of hybrids and has decided to invest more than \$20 billion to pull it off. According to Science and Technology minister Wan Gang, 50% of new cars in China would use electric power by 2020.

Russia represents a large potential market for new cars as well as automotive and aftermarket parts. According to reports published in 2007, cars in Russia on an average are 10 years old, therefore the consumer demand for new cars is high. Toyota introduced its Prius to the Russian market and has got rave response. Likino Bus Manufacturer has come up with a new urban bus model and a pilot batch of these vehicles is expected to be delivered to cities already before the end of the year. Honda Motor is counting on hybrid cars and growing vehicle market in Russia to enter its next phase of expansion in Europe. The Russian hybrid car market is growing at a slow but steady pace and is one of most likely choice for car makers.

The United States of America can be said to be the hub for hybrid cars and has a large market for hybrids. The government is keen on investing \$750 million for boosting the American auto industry and has shown openness towards foreign investors too. Nissan is to make significant green car investment in US and is in talks with the US government for low interest loans for investing \$518 million for producing a fleet of electric cars. Chevrolet Volt, Fisker Karma, Honda FCX Clarity, MINI E, or Mitsubishi i-MiEV, Toyota Prius, Ford Escape and Honda Insight are some of the best selling models. . The US government is encouraging people to choose energy efficient hybrids by giving rebates.

### **Bio-fuels:-**

The bio-fuel industry is poised to make important contribution to India's growing energy needs. The bio-fuels are a great source for clean and environment friendly fuel. Bio-fuel is a huge industry in India with more than \$600 million investment for its research and development. National Biodiesel Mission, an ambitious plan of government of India, is expected to meet country's 20% diesel requirements by 2012. Jatropha is a shrub whose seeds are used for producing biodiesel. Jatropha incentives in India are a part of India's goal to achieve energy independence by the year 2012. General Motors India is investing US\$ 0.5 billion for obtaining biodiesel from Jatropha. They will be testing it on their vehicles at CSMCRI. Indian companies are even trying their luck in other parts of the world. India's Emami biotech is going to invest \$ 80 million in Ethiopia to make bio-fuel. Bharat petroleum, Indian Oil and Hindustan oil are to form a consortium which will invest \$600 million for R&D of bio-fuels. Tata Chemicals has announced to invest \$200 million in ethanol business.

Brazil is the world's second largest producer of ethanol fuel and the world's largest exporter. Brazil is the bio-fuel industry leader and is considered to have the world's first sustainable bio-fuels economy. Petrobras , a leading oil producer in Brazil, is investing \$2.4 billion for bio-fuel refineries and its research. The Brazil Agro Energy Funds consortium is also planning to spend \$2 billion in sugar and ethanol mills. Brazil highly uses bio ethanol as a flex fuel. The Japanese government is also in talks for \$8 billion collaboration with Brazil. There are 43 biodiesel plants operational in Brazil with a capacity of more than 3.6 million liters per year. The **Sugarcane Technology Centre, a privately-funded research institute** in Sao Paulo, played a key part in improving ethanol production technology with an investment of around \$ 20 million. Today 45% of Brazil's vehicles are running on bio-fuels and the market is still growing and the government has announced to increase the bio-fuel content to 5% by next year.

China's bio-fuel industry is booming and the rapidly growing market has been the hotspot in the past few years. In order to reduce the country's growing dependence on imported oil, China has been encouraging the production of bio-fuel such as ethanol and methane from renewable resources. Once an exporter, China now imports at least 43 percent of its oil supply. The Chinese government along with domestic companies sees an investment of around \$13 billion in the coming few years for bio-fuel research and development purposes. An industry chain has been developed by Novozymes ,

China National Cereals, China Oil & Foodstuff Corp (COFCO) and top Asian refiner China Petroleum and Chemical Corp (Sinopec) in February for collecting agricultural waste, processing it into bio ethanol and distributing the clean fuel through petrol stations. The automotive companies are also coming forward and making investments for the green fuel. Biofuel industry in China is enjoying promising prospect and China may gradually emerge to be leader in the bio-fuel sector.

Russia has little domestic demand for bio-fuel, as it has abundance of natural gas and petroleum. However, the alternative energy sources have entered the Russian consciousness and a lot of activity has been seen in the bio-fuel sector. The first bio-fuel plant in Russia is expected to start functioning by the end of 2009. Russia is slow but it has finally joined the race for bio-fuel production.

USA is world's largest bio-fuel producer and mainly produces biodiesel and ethanol fuel using corn as the main feedstock. ExxonMobil is making an investment of \$600 million in the R&D of bio-fuels. Enerkem is pitching in \$250 million for the production of second generation bio-fuels. The total investment for bio-fuels is more than \$13 billion and continuous research is going on to meet the country's growing energy demands.

### **Solar:-**

Till date, solar vehicles have not attained the status of day-to-day transportation devices but are primarily being used as demonstration vehicles. Several engineering exercises are carried out on solar vehicles and often they are funded by government agencies. Solar car racing, as a sport, is also gaining popularity.

The investment in the solar energy sector in India has shown a considerable rise in recent years, it rose from \$18 million in 2007 to \$ 347 million in 2008. India's Solar Mission Plan has been praised by many organizations. The Bangalore based car manufacturer, Reva, will be coming up with its own version of solar paneled cars in the coming years.

Brazil is the 10<sup>th</sup> largest energy consumer and has the total installed photovoltaic power capacity of 12 to 15 MW. The Brazilian ministry has planned \$15 million investment in the solar energy sector. In the automotive sector the solar power is still in the research phase and no promising results have come to light as of now.

China is investing a lot of money in its national solar plan which could result in China becoming the world's largest solar energy harvester. China is in effort to make solar energy the nation's main energy provider by 2050. Taiwanese government has given an approval for investing \$600 million over the span of next five years in areas of green energy, majorly solar. A Chinese car manufacturer has produced the nation's first solar powered car which is put out at a price of \$5560. China has many solar powered bikes running on its roads. Research is on for producing solar powered vehicles commercially.

Russia in a country having rich natural resources and it has been estimated that Russia's gross potential for solar energy is 2.3 million tce(tonnes of coal equivalent). The solar energy field is still in incubation

period in Russia and new firms are coming up to tap the nation's vast solar potential. Till date, the solar power has not been put into use for practical day-to-day transportation purposes.

The United States of America has a lot of activity going down in the solar energy sector for quite some time now. There are several agencies doing R&D for harnessing the Sun's energy, Department of Energy's Solar Energy Technology Program being one. The investment in this field is more than a billion USD and its growing gradually. USA sees a lot of solar power racing events and there are several teams in and around America actively participating in such events. University of Michigan's solar car team has won many accolades for their work in this field.

### **Market Penetration:-**

The market for hybrid cars in India is still coping with the social acceptance issues, operational hassles and initial costs. The pricing is another inhibitor for these hybrid cars. So far, not many hybrid cars have been sold in the Indian market. But the car manufactures are upbeat about their upcoming new hybrid launches. Even in the bio-fuel sector, the commercial use has not been started and it is still in the research phase. However, people have happily accepted the fuel cell concept which is evident from the fact that companies are coming up with fuel cell version of their cars like Tata Motors is working on fuel cell project with ISRO for launching a fuel cell powered car by next year.

Brazil is the largest country in terms of hybrid cars and second largest in bio-fuel production. It alone accounts for more than 50% of flex-fuel cars worldwide. The Brazilian streets are full of flex-fuel cars as it has become the choice of the people. Around 8.2 million hybrid cars have been sold in Brazil till date and the number is escalating day-by-day. In the bio-fuel field a lot of investments are being done to cope with the energy demands for a cleaner and healthier Brazil. The fuel cell technology has also taken people's attention and fuel cell buses are plying on the Brazilian roads. People have accepted the alternative propulsion system as a part of their daily lives.

China, one of the biggest economies of the world today, has environmental protection as one of its main motto. Toyota has sold more than 2500 cars of its hybrid model, Prius, in China. China being one of the largest automobile markets in the world, major car manufacturers have established their R&D centers in China. The electric bike market is also booming in China and there are more than 40 million e-bikes on Chinese roads as of in 2009. Solar energy has also made its ways into people's mind and Chinese population is resorting to solar power for a greener China.

The Russian car market is still a bit new to the alternative propulsion concept and the Russian people haven't totally accepted it. Russia is a country having huge amounts of natural resources. The bio-fuel and fuel cell industry is abuzz with new developments and there has been a good response from people

about these alternative systems. There is abundance of solar power to be tapped which the Russian government has made a mandate for a cleaner Russia.

USA is the leader when it comes to alternative energy and in the field of alternative propulsion system again it is the forerunner. There have been more than 25000 hybrid cars sold in 2009 alone which shows the popularity of hybrid cars in States. The bio-fuel sector is on an exponential growth and extensive research activities are being carried out. People are environment conscious and are turning to solar power preserve the nature. The fuel cell Technology has seen a good amount of development in the area and fuel cells are being incepted in the automotive sector. The alternative systems are making their way into people's lives and they are happily accepting the change.

## Challenges

Even the alternative propulsion systems have their fair share of difficulties to cope with. First of all, the infrastructure cost for deploying these systems is going to be huge, several hundred billion dollars. Secondly, social acceptance is another big issue and needs to be resolved tactfully. The alternative system powered vehicles present in the market at present are either very expensive or are performance wise inefficient. Thirdly, the car manufacturers who are not into these alternative systems will not encourage the move as it is going to affect their business badly. Then, there is the food vs. fuel debate which refers to the dilemma regarding the risk of diverting farmlands for bio-fuel production on a global scale. Energy balance issues and efficiency also need to be dealt with.

To sum up, it would be apt to say that the APS still has a long way to go before making its place into people's daily life-cycle.

## Conclusion

The scenario for alternative propulsion system is not shining in some countries as in others. Countries like India and Russia should come up with some incentive regime for promoting the sales of hybrids, electric and fuel cell cars. Moreover, there is no fiscal incentive support from the government for the development of alternate fuel vehicles. United States and China are giving rebates of \$2000 and \$6300 respectively to buyers of hybrid cars and India and Russia need to follow suit for promoting alternative technologies to come up. In India the electric vehicles attract no excise across the country but the incentivisation proposals such as 50% subsidization for indigenous development of hybrids are still pending. Such incentive regimes from the government encourage car manufacturers to develop environment friendly vehicles as well as customers response is boosted due to affordable prices.

The green cars are safer to drive and usually have a longer life. In these green cars since the energy source is clean, their engines tend to last longer and also there is very low investment on refueling or charging the battery. So, the governments worldwide must encourage the R&D both in the public and

private sectors as seen in USA and China for alternative vehicles and the people should opt for these alternative powered vehicles for a cleaner and greener world.

We rated the countries on various alternative propulsion systems in the table below based on public and private investments, government initiatives and policies, and consumer acceptance. 1 is best and 5 is worst.

Country	Fuel Cell	Bio-Fuel	Hybrid	Solar
India	4	3	4	4
Brazil	3	2	2	3
China	2	4	3	2
Russia	5	5	5	5
USA	1	1	1	1

From the above table it is evident that USA is leading in all the sectors but Brazil and China are not far behind. Brazil is projected to leave behind USA in the bio-fuel sector in the coming five years and China is also coming up very fast in the field of hybrid cars. India and Russia still are far behind and the government in these countries needs to work a lot to boost the alternative vehicle sectors on their lands.

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