

AIRMAX GROUP ARTICLE – MAY 2010
HOME HYDROGEN FUELLING STATIONS or HYDROGEN ON DEMAND



Imagine, in the not too distant future, driving your hydrogen car into your garage and filling it up with hydrogen from your very own home fuelling station. Sounds a bit optimistic perhaps, doesn't it?

However, as far off as it sounds, right now there are people working to make this concept a reality.

Steve Perham: Group MD - Airmax Group
May, 2010

For instance, take the Honda Motor Company which in 1997 developed the Home Energy Station that not only refuels a hydrogen car such as the Honda FCX, but it can also power a home or office. The Home Energy Station III uses natural gas and an onboard reformer to separate out the hydrogen for refuelling the car. However, in order to create energy, it runs the hydrogen through a fuel cell and thus generates power for the home as well.



General Motors has announced that they are developing a home hydrogen fuelling station for use with their line of Equinox Fuel Cell vehicles that they began rolling out in limited numbers in 2007. This hydrogen generator will be able to run on either solar energy or electricity.

In 2008, British firm ITM Power announced that they were building a home hydrogen fuelling station that would be available by the end of the 2010. This H₂ refuelling station uses an inexpensive plastic membrane and electrolyzes water to produce the hydrogen. Through economies of scale the price of this unit could drop as low as £3,000.

Honda stated that a Home Refuelling Station, Home Energy Station IV, tested at the Honda R&D Americas facility in Torrance, California will reduce CO₂ emissions by 30% and energy costs by 50% compared to an average home that is on the grid and uses a fuel-powered car.

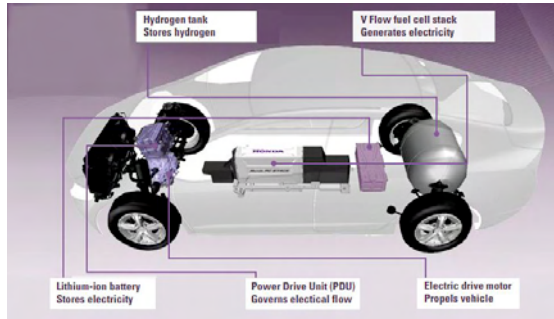
The hydrogen generators and home hydrogen fuelling stations of the future will most likely come in three varieties including electrolysis units, reformers and chemical reaction units. The electrolysis units work by simply splitting water into hydrogen and oxygen, then compressing and storing the H₂ for future use. The reformers use natural gas, methane or another hydrogen-rich gas and separate out the hydrogen to use as fuel. The chemical reaction units use boron,

In January 2010, the Honda Solar Hydrogen Station went into operation at the company's headquarters. The Honda Solar Hydrogen Station is an upgrade to the Home Energy Station IV eliminating the compressor altogether.

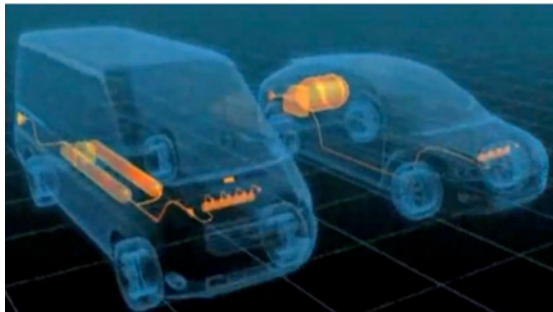


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aluminium or other chemical substances and water to create a reaction generating hydrogen to use for fuel.



Variant 1 - Electric Hybrid



Variant 2 -Internal Combustion Engine and direct Hydrogen Injection

Variant 3 –Hydrogen on Demand

Currently, the hydrogen-on-demand systems that are being developed for the automotive industry either use electrolysis or a chemical reaction in order to generate hydrogen fuel as needed for a car equipped with either an internal combustion engine (ICE) or a fuel cell. The hydrogen-on-demand systems that use electrolysis generally use some other metal catalyst such as aluminium or magnesium to help aid in the process.

The hydrogen-on-demand systems that use a chemical reaction usually start with sodium borohydride (or another boron / hydrogen derivative), which is a hydrogen-rich chemical compound and force a reaction that releases the hydrogen as needed. In the case of sodium borohydride (NaBH₄), the result of the chemical reaction is to degrade into inert salt, which can then be recycled back into sodium borohydride again.

Some of the companies currently developing hydrogen-on-demand technology include Hydrogen Power Incorporated, who have developed a 'Hydrogen Now' system, demonstrated at the 2007 International Auto Show in Seattle, Washington. The 'Hydrogen Now' system was retrofitted inside a 2006 Ford Ranger XL.

In 2002, the Duffy fuel cell boat made waves by testing out a hydrogen-on-demand system developed by hydrogen battery maker, Millennium Cell. The boat also was equipped with a fuel cell. The hydrogen-on-demand Duffy boat used borax as its source for sodium borohydride to power the vessel. Millennium Cell also demonstrated its hydrogen-on-demand systems in the 2001 DaimlerChrysler Town & Country Natrium and the Peugeot-Citroen H₂O concept vehicles.

Millennium Cell has a 5-year \$3 million contract with the Department of Energy to continue research on sodium borohydride technology. Millennium Cell is also working with the Los Alamos National Lab and Dow Chemical on methods to lower the cost of manufacturing the chemical compound.

Samsung Engineering has also developed a prototype scooter that uses sodium borohydride for its hydrogen-on-demand applications to power the vehicle.

So far, hydrogen-on-demand technology has not gained much attention but the implications of such technology are immense. One day in the future, it might just be that the big chemical companies are fighting with the big oil companies over who will be fuelling the nation's cars. Wouldn't this be interesting?

Today, there are many companies claiming to have commercial hydrogen generation units available for sale. Unfortunately, leading-edge technology tends to bring out the scam artists as well. So, a word of caution to the wise, before spending any money ask the company for references from satisfied customers to prove they are legitimate



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vendors. A little caution will go a long way in making sure you're on the leading edge of technology and not on the bleeding edge of technology.

A family vehicle that averages 25 mpg to travel a little over 100 miles per day and uses 30 gallons of petrol per week will dump about 30,000 pounds of carbon dioxide into the atmosphere each year. Even more if you add in all the life cycle processing costs of refining and transportation.

Hydrogen can be produced from water, sewage, household rubbish, landfill mass, agricultural biomass, paper product wastes and many other waste streams that contain hydrogen-bearing compounds.

Hydrogen can be used as a clean burning, non-polluting fuel in virtually every application where other fuels are used today.

Because hydrogen is pollution free, small personal or local power plants can be designed to utilise much of the energy we now throw away. Cogeneration (including Combined Heat and Power "CHP" Systems) fuelled by hydrogen can at least double energy utilisation compared to present practices.

These power plants could be mass-produced so that the cost per kilowatt of capacity will be substantially less than that of large conventional power plants.

All fuels need air (oxygen) for combustion. Hydrogen is the only common fuel that is not chemically bound to carbon; therefore when hydrogen burns in air it produces only heat energy, water and possibly trace amounts of oxides of nitrogen. Water and oxides of nitrogen produced by thunderstorms are natural in our atmosphere.

When hydrocarbon fuels (coal, oil, natural gas, propane, wood) burn they form serious pollutants like carbon monoxide (a poisonous gas which is produced by incomplete combustion) carbon dioxide (a greenhouse gas), an extensive list of complex hydrocarbon chemicals and quantities of particulate matter including carcinogens.

Hydrogen is the only fuel whose production and end use can both contribute directly to eliminating many of our most insufferable environmental, economic, and health problems.

The Solar Hydrogen Economy will never run out of energy to produce energy-intensive goods and services and thus can provide

anti-inflationary benefits and full employment opportunities.

As a gas or a liquid, hydrogen can easily be transported, stored and ultimately it can be used in every application where fossil fuels are used today. This makes hydrogen an ideal, non-polluting energy carrier.

Unlike electricity, whose production as a secondary energy medium must be juggled among expensive central power plants to accommodate peak usage periods, hydrogen can be transported and stored for industrial and domestic needs and to quickly make electricity at virtually any time.

It is less expensive to move hydrogen across the continent as a compressed gas by pipeline than an equal amount of electrical energy by the electric grid.

Subterranean pipelines are far less susceptible to damage by ice storms, tornados, hurricanes and vandalism than electricity grids.

Liquid hydrogen is safer than oil and an economical choice for moving energy across the oceans.

Renewable Hydrogen could be cost-effectively produced at 75 dollar cents per Gallon Gasoline Equivalent of (GGE). This estimate is based upon large-scale extraction of hydrogen from biomass wastes or solar thermal extraction techniques utilising large parabolic solar concentrators called Gensets. Solar Dish Gensets hold the world efficiency record for converting solar energy to electricity.

Burning hydrogen does not contribute to the Greenhouse Effect, stratospheric ozone depletion, or acid rain. Transition to a hydrogen energy distribution system could restore the atmosphere to natural conditions prevailing before these anomalies became serious problems.

Hydrogen can be stored and supplied through the same pipeline network that now supplies natural gas. Depleted natural gas fields and similar geological formations could also be utilised for storing hydrogen.

Over 400 cities once used hydrogen in a mixture called "town gas" for illumination, cooking, and heating before pipelines were established for delivering natural gas from oil and gas fields. Natural gas was cheaper because it was subsidised and came from the ground as a pressurised gas that required little or no preparation for market.



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Plants and animals naturally produce hydrogen. Hydrogen is not toxic.

Existing vehicles can be economically converted to burn hydrogen fuel.

To improve air quality governments have set low emission standards for cars. A vehicle converted to operate on hydrogen easily meets this standard and can actually improve upon it by cleaning the air through which it travels as it reduces atmospheric concentrations of carbon monoxide, diesel soot, tire particles and unburned hydrocarbons by converting these pollutants into carbon dioxide and water. This air cleaning capability provides a Minus Emissions Vehicle (MEV).

A special class of MEV is a vehicle that uses hydrogen made from renewable resources. It is called Renewable Energy Vehicle - Minus Emissions or "REV-ME."

MEV engines using hydrogen will last much longer and start faster in any weather.

The lubricating oil in a MEV engine will remain clean for extended periods of time. There are no sulphur or carbon compounds or particulates to degrade the engine oil.

Hydrogen is the best way to power future fuel cell electric automobiles or existing vehicles that have internal combustion engines.

Hydrogen fuel cells utilise the energy of a reaction between hydrogen and oxygen, which is converted directly and continuously into electrical energy for electric vehicle propulsion. Hydrogen batteries or fuel cells continue to produce electricity as long as hydrogen is supplied for the process of converting it into water and producing electricity.

Another advantage of a hydrogen battery or fuel cell is that the device also produces clean, potable water, which is currently used on manned spacecraft and could also be useful in solving critical drinking water problems wherever potable water shortages exist.

One kilogram of hydrogen when combined with oxygen will make nine kilograms of water. Therefore a hydrogen power plant could make valuable quantities of high quality water in addition to producing electricity.

Presently (2010) civilisation depends upon annually burning over one million years' of fossil coal, oil and natural gas accumulations.

The estimated total petroleum reserves in the earth's crust are about one trillion barrels. Oil consumption is at 25 billion barrels per year and increasing at 1-1/2% per year. At current rates of consumption, measured against known reserves, there is only a 30 year supply of oil in the Earth's crust. Even if the reserve estimate were doubled it is a moral imperative that we take immediate action to develop a sustainable Solar Hydrogen economy.

Energy Snap Shot

In 1993, the United States consumed roughly 16.8 million barrels of oil a day. In 2003, that number increased 16% to 20 million barrels a day. Major consuming countries in Europe (Germany, France, Italy, the United Kingdom, Spain, Belgium and the Netherlands) consumed about 10.5 million barrels of oil a day in 1993. In 2003, they were only consuming 11.4 million barrels a day. Now, the entire EU consumes about 14.5 million barrels a day with the addition of 20 other states.

Is it safe to assume that these 20 other member states consume 3.1 million barrels of oil a day, or 155,000 barrels a day each? That wouldn't exactly be fair...

Poland, for example, consumes 173.9 million barrels a year, or 476,000 barrels a day, on its own. So what does this mean?

Could Europe be cutting its consumption of oil?

In 1993, Germany was consuming 2.89 million barrels of oil a day. By 2003, the country was consuming only 2.68 million barrels a day. Today, they are consuming 2.44 million barrels a day, nearly a 9% drop.

The United Kingdom cut its consumption from 1.83 million barrels a day in 1993 to 1.72 million barrels a day in 2003. It now only consumes 1.66 million barrels a day -- a 3.5% drop.

Spain, whose oil consumption rose 46% between 1993 and 2003, consumes only 2.5% more oil than it did four years ago.

Italy's oil consumption, which declined 1% between 1993 and 2003, has declined a further 7.5% in the last four years.

The European Union has been extremely proactive in cutting its oil consumption over the years. High vehicle fuel taxes funnel cash into renewable energy research. Not likely to be seen in the United States with folks complaining when gasoline costs \$3 a gallon.



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The EU has some ambitious renewable energy standards, too, that are pushing countries to work hard at achieving certain percentages of energy generation from renewable sources like wind power and solar energy.

In 2000, the EU declared a target of 12% of total energy consumption and 22.1% of electrical consumption to be derived from renewable resources by 2010. But other countries are even more motivated.

Denmark and Finland are striving for 30% renewable energy based by 2010. Will they make it?

The European Commission told IHS, a global provider of technical information in the energy and engineering fields, "A decade ago, the EU started working towards a target of a 12% share of renewable energy in its overall mix by 2010. Although renewable energy consumption has increased by 55% since, its share is unlikely to exceed 10% by 2010."

But far from giving up, the EC says, "The EU, therefore, needs a step change to provide a credible long-term vision of the future of renewable energy."

Without ambitious goals, the EU would not have increased renewable energy sources' share of electricity generation by 55% in the past 10 years.

Facts

Current energy systems are seriously inadequate in terms of ability to meet increasing demand far into the future.

A transition to a hydrogen energy system will be the most significant, ongoing job creation opportunity ever conceived for both blue and white-collar workers.

Hydrogen can be the safest of all fuels. Gaseous hydrogen is 14-times lighter than air; therefore it rapidly disperses into the atmosphere in the event of an accidental release. This is not true of most other fuels. Other fuels have a much greater "dangerous time" until they are dispersed from the location of accidental release.

Hydrogen is already used to produce countless products and to enhance many industrial processes.

The United States produces more than 100 billion cubic feet per year of hydrogen for industry and for the space programme.

The largest user of hydrogen is the petroleum industry for converting crude oil

into fuel, fertilisers, and hundreds of chemicals.

Not one person sustained hydrogen burns in the 1937 Hindenburg accident. Seven million cubic feet of hydrogen, equal in volume to a structure three football fields in size and 49 ft. in height, burned in less than one minute. However, diesel fuel that was stored for the propulsion engines fell to the ground and continued to burn for many hours.

If liquid hydrogen is spilled it will very rapidly evaporate, leaving no pollution or toxic residue.

Hydrogen can be stored at room temperatures as a hydride (hydrogen chemically combined with a metallic element) under little or no pressure and in a volume that is less than if it were a super-cold liquid.

Carbon is a valuable by-product of separating hydrogen from hydrocarbon compounds. Over \$5.00 worth of carbon products can be extracted from a gallon of fuel. The hydrogen left over could be used in cars that clean the air of pollution caused by those vehicles using hydrocarbon fuels. In the process; pollution, carbon monoxide and hydrocarbons are transformed into carbon dioxide and water.

Carbon is the most versatile of all elements. With it we can make materials that are lighter than aluminium, stronger than steel, and that conduct heat or electricity better than copper.

About 74% of our landfills are hydrocarbons that can be converted into non-polluting hydrogen fuel and superior building materials.

It is not rational to burn petro-carbons and deny future generations their opportunity to utilise fossil hydrocarbon reserves to make plastics, synthetic fabrics, lubricants, solvents, and carbon-fibre reinforced products that are stronger than steel and countless other new products that are yet to be developed.

Hydrogen packs more chemical energy in a pound for pound comparison than with any other fuel. Two pounds of hydrogen provides as much energy as a gallon of fuel. About 2.2 gallons of water can supply enough hydrogen to replace one gallon of fuel.

Hydrogen can be used more efficiently than petrol or other fossil fuels.

A Solar-Hydrogen powered heat pump could cool your house in summer and heat it in winter.



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In many ways Germany, Saudi Arabia, Russia, Canada and Japan are leading in research and development of hydrogen fuel and its applications. Mercedes and BMW have experimental fleets of hydrogen-powered automobiles. Japanese automakers are testing hydrogen-powered cars.

The United States could significantly transition to renewable hydrogen fuel by the year 2020.

Using a small portion of total land area, countries can manufacture enough Solar-Hydrogen to supply their entire energy requirement. Solar hydrogen could make them fuel-independent and pollution free for as far into the future as the sun will shine.

Development of hydrogen energy systems would offer protection from possible national security disasters precipitated by a geopolitical upheaval beyond any control.

Hydrogen could represent a lucrative cash crop for farmers in areas where there is abundant wind, solar radiation, geothermal, or biomass resources. Many farmers could profit financially by converting biomass and animal wastes into hydrogen through a process of bio-remediation (utilising micro-organisms to break down unwanted or excess materials).

Using solar thermal electricity to make hydrogen is 30 times more efficient than the best green plants' photosynthesis process. Earth's human population of 7 billion cannot wait for another "dinosaur age" to replenish fossil fuels.

Introducing hydrogen (2%-20%) into internal combustion engines, that are currently using fossil fuels like fuel, diesel, or natural gas, increases the efficiency of combustion, improves mileage and reduces pollutants to a remarkable degree.

A substantial part of the expense in building and operating a fossil fuel power plant is devoted to disposing of heat from wasted energy. Most conventional power plants throw away 60% to 80% of the energy that the customer pays for in addition to the high cost of building and operating "condensers" to reject very large amounts of heat into the environment.

A conventional nuclear or fossil-fuelled central power plant can deliver only about one-third of the energy in the fuel in the form of electricity. Heating the environment wastes the remaining energy. A hydrogen-fuel plant can deliver 70% or more of the energy as a combination of "cogenerated"

heat and electricity products in a pollution free application.

Implementation of a worldwide solar hydrogen energy system will be tantamount to a Second, Clean Industrial Revolution or the Renewable Resources Revolution.

California, Arizona, Nevada, Oregon, Utah, Idaho, New Mexico, North Dakota, Wyoming, Montana, or Texas could provide endless supplies of Solar-Hydrogen for the United States and other countries and could eventually be richer than Saudi Arabia by making and selling Solar-Hydrogen

Hydrogen is the simplest, lightest and most abundant chemical element in the universe.

On our planet hydrogen is abundant but it is usually combined with other elements. When combined with oxygen it is called water; when combined with carbon it is called a hydrocarbon.

Hydrogen is colourless, odourless, tasteless and non-toxic.

To make hydrogen available for use as a fuel, energy is required to separate it from other elements. Solar energy is the most abundant available source of energy on earth. Solar energy reaches the Earth at a rate that is 18,000 times the energy consumed by human activities and is an ideal source for separating hydrogen from other elements.

Solar hydrogen fuel can be produced to supply a clean sustainable supply of fuel for virtually all human energy needs, FOREVER.

Forest lands, which are being decimated for heating and cooking purposes by people in developing nations, can be preserved by utilising hydrogen as fuel.

Most developing nations are endowed with sufficient wind, water or sun power to make hydrogen for villages and where appropriate on a large scale for urban areas.

Using Solar Hydrogen could eliminate strip mining coal that defaces and environmentally destroys huge areas.

Vast quantities of hydrocarbon seepage from tank farms, pipelines and 200,000 fuel service station tanks that now pollute our soil and aquifers would be virtually eliminated by a transition to hydrogen fuel.

Proven technologies are available to make, store, and use solar hydrogen.

Hydrogen produced by bioremediation in China or India is chemically and physically the same as hydrogen produced by wind power on a Nebraska farm. Hydrogen can



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therefore be used as a universal medium of energy exchange.

Pollutants from reliance on finite fossil fuels and nuclear energy are ultimately carried by the atmosphere and river systems to the oceans where they affect phytoplankton (that produce 80% of the earth's oxygen), flora and fauna of all kinds, particularly those marine species that comprise the ocean fisheries upon which nearly all populations rely for a basic food source.

Energy providers could reduce their costs of operation by a very substantial margin through elimination of most exploration, drilling, mining, milling, refining and other cost-intensive practices. These firms could reap even larger profits than they do now by actively participating in the transition to hydrogen energy systems.

Burning any fossil fuel creates pollutants that cause millions of people to suffer from lung, respiratory, and allergic types of illness. Burning hydrogen will eliminate much suffering and productivity losses and would substantially reduce health care costs.

If done to optimise economies of scale, many methods of producing hydrogen will be cost competitive with fossil fuels or nuclear energy.

Importing crude oil costs the United States two billion dollars every week. Using hydrogen in place of oil could reduce our trade deficit by billions of dollars. Even larger savings are available by eliminating the large military expenditures required to provide deliveries of foreign oil to the U.S.

Socially relevant costs of producing and bringing any fuel to market must also include such factors as pollution and other short and long-term environmental costs as well as direct and indirect health costs. When these factors are taken into consideration, together with its initial cost economy-of-scale competitiveness, hydrogen is surely the most logical choice for a worldwide energy carrier.

It seems like every day there is a new announcement in the news about vehicles powered by fuel cells. The promises are tantalising, since using hydrogen in existing engines can actually clean the air and fuel cells have the potential to increase the efficiency of cars while significantly reducing air pollution. At the same time, there have been news stories for decades about the problems associated with petroleum. Everything from oil spills to ozone depletion to global warming gets blamed on our

dependence on fossil fuels. These two forces are leading the world toward what is broadly known as the hydrogen economy. If the predictions are true, over the next several decades we will all begin to see an amazing shift away from the fossil fuel economy we have today toward a much cleaner hydrogen future.

Can society actually make this shift, or will the technological, economic and political barriers keep us dependent on petroleum and other fossil fuels for the next century and beyond?

In this article, you will learn about the benefits of a hydrogen economy, along with its potential problems. We will also examine some of the technology that would make the transition possible.

Problems with the fossil fuel economy

Currently, most of the world is locked into what could be called the fossil fuel economy. Almost exclusively petroleum products like petrol and diesel fuel our vehicles, trains and planes. A huge percentage of our power plants use oil, natural gas and coal for their fuel. If the flow of fossil fuels to any country were ever cut off, their economy would come to a halt. There would be no way to transport the products that factories produce. There would be no way for people to drive to work. The whole economy, and in fact the whole of western society, currently depends on fossil fuels. While fossil fuels have played an important role in getting society to the point it is at today, there are four big problems that fossil fuels create:

Air pollution - When cars burn fuel, they would ideally burn it perfectly and create nothing but carbon dioxide and water in their exhaust. Unfortunately, the internal combustion engine is not perfect. In the process of burning the fuel, it also produces: Carbon monoxide, a poisonous gas and Nitrogen oxides, the main source of urban smog Unburned hydrocarbons are the main source of urban ozone

Catalytic converters eliminate much of this pollution, but they aren't perfect. Air pollution from cars and power plants is a real problem in big cities.

Environmental pollution - The process of transporting and storing oil has a big impact on the environment whenever something goes wrong. An oil spill, pipeline explosion or well fire can create a huge mess. The Exxon Valdez spill is a well-known example of the problem, but minor spills happen constantly.



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Global warming - When you burn a gallon of fuel in your car, you emit about 20 pounds of carbon dioxide into the atmosphere. If it were solid carbon, it would be extremely noticeable -- it would be like throwing a 5-pound bag of sugar out the window of your car for every gallon burned. But because the 5 pounds of carbon comes out as 20 pounds of invisible carbon dioxide gas, most of us are oblivious to it. The carbon dioxide coming out of every fossil fired power plant and car's tailpipe is a greenhouse gas that is slowly raising the temperature of the planet. The ultimate effects are unknown, but there are strong indications that we are experiencing dramatic climate changes that affect everyone on the planet. For example, melting glaciers and polar ice caps raise the sea level, causing flooding of coastal cities. Fresh water dilution of the polar ocean waters can cause the sea currents to change. That's a big side effect that could cause Iceland, Ireland, England and France to experience much cooler weather. Similar changes would be expected for northern areas of both coasts of North America.

Dependence - Most industrialised countries cannot produce enough oil to meet demand, so they import it from oil-rich countries. That creates an economic dependence. When Middle East oil producers decide to raise the price of oil, the rest of the world has little choice but to pay the higher price.

Advantages of the Hydrogen Economy

The hydrogen economy promises to eliminate all of the problems that the fossil fuel economy creates. Therefore, the advantages of the hydrogen economy include:

The elimination of pollution caused by fossil fuels - When hydrogen is used in a heat engine or fuel cell to create power, it is a completely clean technology. The only by-product is water. There are also no environmental dangers like oil spills to worry about with hydrogen.

The elimination of greenhouse gases - If the hydrogen comes from the electrolysis of water, then hydrogen adds no greenhouse gases to the environment. There is a perfect cycle -- electrolysis produces hydrogen from water, and the hydrogen recombines with oxygen to create water and power in a fuel cell.

The elimination of economic dependence - The elimination of oil means no dependence on the Middle East and its oil reserves.

Distributed production - Hydrogen can be produced anywhere that you have electricity and water. People can even produce it in their homes with relatively simple technology.

The problems with the fossil fuel economy are so great, and the environmental advantages of the hydrogen economy so significant, that the push toward the hydrogen economy is very strong.

Technological Hurdles

The big question with the hydrogen economy is, "Where does the hydrogen come from?" After that comes the question of transporting, distributing and storing hydrogen. Hydrogen tends to be bulky and in its natural gaseous form. Once both of these questions are answered in an economical way, the hydrogen economy will be in place.

Where does the hydrogen come from?

One of the more interesting problems with the hydrogen economy is the hydrogen itself. Where will it come from? With the fossil fuel economy, you simply pump the fossil fuel out of the ground and refine it. Then you burn it as an energy source. Most of us take oil, fuel, coal and natural gas for granted, but they are actually quite miraculous. These fossil fuels represent stored solar energy from millions of years ago. Millions of years ago, plants grew using solar energy to power their growth. They died, and eventually a small fraction of this biomass turned into oil, coal and natural gas. When we pump oil from the ground, we tap into that huge solar energy storehouse without paying the replacement price. Whenever we burn a gallon of fuel, we release stored solar energy. In the hydrogen economy, there is no storehouse to tap into. We have to actually create the energy in real-time.

There are numerous possible sources for the hydrogen such as:

Electrolysis of water - Using electricity, it is easy to split water molecules to create pure hydrogen and oxygen. One big advantage of this process is that you can do it anywhere. For example, you could have a box in your garage producing hydrogen from tap water, and you could fuel your car with that hydrogen.

Reforming organic substances - Oil and natural gas contain hydrocarbons -- molecules consisting of hydrogen and carbon. Using a device called a fuel processor or a reformer, you can split the hydrogen off the carbon in a hydrocarbon relatively easily and



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then use the hydrogen. Reformers discard the leftover carbon to the atmosphere as carbon dioxide.

This option is, of course, slightly perverse. You are using fossil fuel as the source of hydrogen for the hydrogen economy. This approach reduces air pollution, but it doesn't solve either the greenhouse gas problem (because there is still carbon going into the atmosphere) or the dependence problem (you still need oil).

However, it may be a good temporary step to take during the transition to the hydrogen economy. When you hear about "fuel-cell-powered vehicles" being developed by the car companies right now, almost all of them plan to get the hydrogen for the fuel cells from fuel using a reformer. The reason is because fuel is an easily available source of hydrogen. Until there are "hydrogen stations" on every corner like we have petrol stations now, this is the easiest way to obtain hydrogen to power a vehicle's fuel cell.

Reforming biomass - If the organic substance is sewage, garbage, agricultural wastes, or forest slash however releasing the hydrogen and venting the carbon dioxide is no worse than the natural result of having such wastes rot or burn into the atmosphere.

Pyrolysis: Another technology for producing hydrogen is to break organic molecules into hydrogen and carbon. An oxidant free chamber can be heated to sufficient temperature to break hydrogen away from carbon and allow the carbon to be sequestered to build better solar collectors, wind and wave turbines, and wave machines for harnessing more renewable energy.

The interesting thing about these comparisons is that there are numerous ways to supply the hydrogen needed. To have a sustainable hydrogen economy, the hydrogen must be derived from renewable sources rather than fossil fuels so that we stop changing the atmosphere with carbon particles and gases. Having enough electricity to separate hydrogen from water, and generating that electricity without using fossil fuels, will be the biggest change that we see in creating the hydrogen economy.

Where will the electricity for the electrolysis of water come from?

To date, the majority of electricity produced comes from coal or natural gas. All of that generating capacity will have to be replaced by renewable sources in the hydrogen economy. In addition, all of the fossil fuel

energy now used for transportation (in cars, trucks, trains, boats, planes) will have to convert to hydrogen, and much of that hydrogen will be created with electricity, as well. But it is possible to use hydrogen in engine-generators with heat recovery systems to double the energy utilisation efficiency of conventional power plants.

Right now there are several different ways to create electricity that do not use fossil fuels:

- Nuclear power
- Hydroelectric dams
- Solar cells
- Wind turbines
- Geothermal power
- Wave and tidal power
- Co-generation (For example, to create power a landfill might burn methane that the waste produces.)

Nuclear power produces around 11% of the world's energy needs, and produces huge amounts of energy from small amounts of fuel, without the pollution that you'd get from burning fossil fuels. Solar, wind, geothermal and other sources generate only 5% of the power.

Nuclear power have waste disposal, potential terrorist dirty bomb problems along with political problems. Nuclear plants require enormous subsidisation, long lead times and 15 or more years of operation to provide energy payback of fossil resources used to mine, refine, and construct the massive power plants needed. Carbon dioxide and other fossil emissions required to prime the nuclear power pump comes first then after a long time there may or may not be an energy payback. Wind, wave and solar power systems currently have cost and location problems.

In the future, barring some technological breakthrough, it seems likely that one of two things will happen to create the hydrogen economy: Either nuclear-power or various forms of solar, wind, and wave power generating capacity will increase dramatically.

Hydrogen production is probably the biggest hurdle for the hydrogen economy. Once the technology is refined and becomes inexpensive, hydrogen engines and fuel-cells will power farms, vehicles, homes, and factories.



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How do you store and transport the hydrogen?

At this moment, the problem with putting pure-hydrogen vehicles on the road also encounters the storage/transportation problem. Hydrogen is a bulky gas, and it is not nearly as familiar to work with as existing fuels. Compressing the gas requires energy, and moderately compressed hydrogen contains far less energy than the same volume of fuel. However, solutions to the hydrogen storage problem are surfacing.

For example, hydrogen can be stored in a solid form in hydrides and in chemicals such as a chemical called sodium borohydride, and this technology has appeared in the news because Chrysler is testing it. This chemical is created from borax (a common ingredient in some detergents). As sodium borohydride releases its hydrogen, it turns back into borax so it can be recycled.

Once the storage problem is solved and standardised, then a network of hydrogen stations and the transportation infrastructure will have to develop around it. The main barrier to this might be the technological sorting-out process. Stations will not develop quickly until there is a storage technology that clearly dominates the marketplace. For instance, if all hydrogen-powered cars from all manufacturers used sodium borohydride, then a station network could develop quickly; that sort of standardisation is unlikely to happen rapidly, if history is any guide.

There might also be a technological breakthrough that could rapidly change the playing field. For example, if someone could develop an inexpensive rechargeable battery or practical flywheel propulsion system with high capacity and a quick recharge time, electric cars would not need fuel cells and there would be no need for hydrogen on the road. Cars would recharge using electricity directly but it would be preferable for the electricity to be produced from renewable resources in part by hydrogen cogeneration systems that double the energy utilisation efficiency of conventional power plants.

Prospects for the future

You will hear more and more about the hydrogen economy in the news in the coming months, because the drumbeat is growing louder. The environmental problems of the fossil fuel economy are combining with breakthroughs in fuel-cell technology, and the pairing will allow us to take the first steps.

The most obvious step we will see is the marketing of fuel-cell-powered vehicles. Although fuel and reformers will power them initially, fuel cells embody two major improvements over the internal combustion engine:

- Fuel cells may be about twice as efficient in some applications but this is also true of diesel engines converted to hydrogen compared to present fuel engines.
- Converted internal combustion engines and fuel cells can significantly reduce air pollution in cities.

Fuel-powered fuel-cell vehicles are an excellent transitional step because of those advantages.

Moving to a pure hydrogen economy will be harder. The power-generating capacity will have to be switched to renewable sources of energy, and the marketplace will have to agree on ways to store and transport hydrogen.

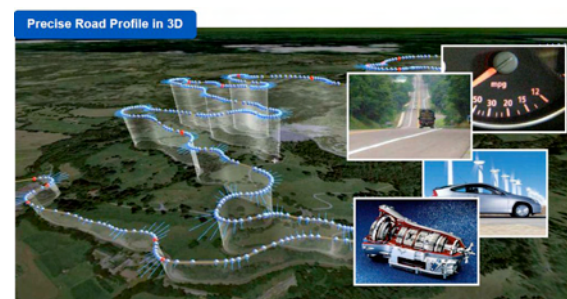
These hurdles mean that many new jobs will be created as we convert the fossil fuelled Industrial Revolution to the Sustainable Prosperity Revolution.

So what is Airmax Group's play in all of this?

Airmax is contributing to the hydrogen fuel sector by working with partners to improve the electronics interface of the vehicle.

Its telematics CANbus module adds Horizon data from Navteq to inform the vehicle of the road conditions ahead; thus forecasting the demand for hydrogen.

This smart technology will also improve Hybrid technology and add a new level of management to control the demand for electric power kick in.



In partnership with The Cell, from Colorado, (www.thecell.com). Airmax is trialling a new



HYDROGEN AS A FUEL OR FUEL SUPPLEMENT

electronics interface to monitor temperature of the engine, oxygen sensors and HHO volume.



To date this has led to an average of 17% fuel saving on DAF Trucks and improved driveability. These naturally aspirated engines are injected with HHO via the inlet manifold based on the vacuum inhalation. Trials are underway on direct fuel injection.



Tests have shown up to 30% on static engines

"While we still believe fuel cells are the best hope for a zero-emission product to replace the internal combustion engine in the future, (The hydrogen I.C.E.) offers a great opportunity to improve hydrogen infrastructure with a vehicle that is comparatively easy to produce and seamless in customer operation."

--John Wallace, Executive Director of Ford's TH!NK Group

Airmax Group is one of Europe's most successful innovators in the supply of telematics solutions to the commercial and business fleet markets. A recently highly commended runner up for the 'Green Fleet' IT Innovation Award, the Company has in excess of 25,000 vehicles fitted with its telematics units providing data across a diverse range of applications such as fleet management, driver performance profiling, vehicle diagnostics and CO₂ emissions.

For more information about Airmax Group Ltd visit www.airmaxgroup.com or contact us on info@airmaxgroup.com

References

Marshall Brian and Roy McAlister

American Hydrogen Association

