The emerging fuel of the future

Hydrogen fuel, or more commonly known as fuel cell, is an electrochemical device that produces electricity from the chemical reaction of hydrogen and oxygen. The combination of hydrogen and oxygen produces water as its main byproduct. Since only water and heat is produced it has no hazardous emissions making it friendly to our environment.

The water produced can be used for life-support purposes, as in the case of the fuel cells carried on board the Gemini spacecraft (Huang 15). Fuel cell is more like a battery that produces electrical energy from chemical reactions. Although, unlike ordinary batteries fuel cells do not require recharging and continuously provides electricity for as long as hydrogen fuel (H2) is continuously supplied. Fuel cell are also very efficient since it does not involve low efficiency combustion, so that if all of the energy can be harnessed it can attain a very high efficiency. Hydrogen fuel (H2) may come from a variety of sources such as electrolysis of water, from the hydrocarbons of natural gas or even from gasoline.

The electricity produced can be used in many applications such as generators in power plants, fuel for automobiles or even a battery in your laptop. Recently, major car manufacturers are in the process of developing fuel cell powered vehicle. The Department of Energy (DOE) also offered funding to research of fuel cells. There is massive indication that fuel cell will replace gasoline in the future due to its high efficiency and very low emission. The fuel cell system is consists of two electrodes sandwiched around an electrolyte (fuelcell. org).

Hydrogen fuel is added into the anode while oxygen from the environment enters the cathode. Through the anode catalyst, hydrogen brakes into H+ ions. These hydrogen ions will flow through the polymer electrolyte membrane into the cathode while the flow of electrons can be used as electricity. The chemical reaction at the anode consist of $2H_2 \Rightarrow 4H^+ + 4e^-$, while at the cathode $O_2 + 4H^+ + 4e^- \Rightarrow 2H_2O$. Combining the two results in a net reaction $2H_2 + O_2 \Rightarrow 2H_2O$. The continuous supply of Hydrogen (H_2) at the anode would result in the continuous production of electricity.

Hydrogen fuel is one the most probable candidate for replacement of gasoline in the future. No other energy generation technology offers the combination of benefits that hydrogen fuel. Ideally, fuel cells can generate electricity at an extremely high efficiency 83% and even with losses in the actual process it is still more efficient than other fuel counterpart which uses combustion. Combustion fuel losses from the two stage thermodynamic conversion, first the conversion to heat, then from heat to mechanical energy.

Hydrogen, with an atomic weight of 1. 0, is the lightest of the elements. Liquid hydrogen has a density of 0. 07 grams per cubic centimeter, whereas gasoline about 0. 75 g/cc.

The advantage is that it stores approximately 2. 6 times the energy per unit mass compared to gasoline. Hydrogen fuel basically has zero emissions because the byproduct is only heat and water. Awareness in the greenhouse effect due to the buildup of carbon dioxide in the atmosphere makes emission as the primary concern.

Every country in the world is pushing for reduction in the emission of automobiles to reduce air pollution. This further leverages the development of hydrogen fuel. Fuel cells which produces hydrogen from the hydrocarbon of natural gas through a device called a reformer still produces emission but the emissions are very minimal compared to gasoline and diesel. In addition to low or zero emissions and high efficiency, fuel cells offers reliability, multi-fuel capability, flexibility, durability, and ease of maintenance. Fuel cells are also scalable and can be stacked like batteries until the desired power output is reached.

Since fuel cells operate silently, they reduce noise pollution and the waste heat from a fuel cell can be used to provide hot water or space heating for a home or office. Present developments of hydrogen fuel have not reach a point where it becomes economically viable for home and automotive use. There are still roadblocks that would probably take years to overcome. One of the roadblocks is the size of the fuel tank.

Due to Hydrogen's low density, a hydrogen fuel tank will have three times the size of a gasoline tank. Recent developments in the automotive industry offer improvements in the reduction of size. The current FCX technology of Honda uses compressed hydrogen storage with their fuel stack technology and the use of ultra-capacitor (McCormick 10). Another roadblock is related to safety, liquid hydrogen is cold enough to freeze air, and accidents have occurred from pressure build-up following plugged valves. In a collision the hydrogen tank may explode, as can a gasoline tank. The danger is somewhat less with hydrogen than with gasoline, because the hydrogen dissipates rapidly.

The release of hydrogen into a confined space like a garage or tunnel risks an explosion. Further research on the fuel cell technology includes increase in safety of use so in the future this may no longer be a problem. Another problem in storage involves insulation. Since the insulation can't be perfect, the hydrogen will gradually evaporate, typically 1. 7 percent per day. This is quite fast for a car to sit for days or months in a between uses.

A tank of compressed hydrogen holding enough to get to a hydrogen station would remedy this. The last obstacle is that Hydrogen does not occur free in nature in useful quantities. It has to be made, usually by splitting water H2O to get the hydrogen. Law of conservation of energy in thermodynamics tells us that this requires all the energy you are going to get from burning the hydrogen and a bit more on account of inefficiencies.

Therefore, hydrogen is an energy transfer medium rather than a primary source of energy. Hydrogen is obtained by splitting water (H2O) into hydrogen and oxygen. So to make it cheap the energy to split the water should be from sources such as nuclear or solar. Nuclear is cheaper but the safety concerns associated with nuclear plants makes it an inappropriate method for the present time.

Developments in the safety of nuclear plants in the future would make the production of hydrogen through nuclear energy feasible. Presently, research and studies have done major progress in the development of hydrogen fuel. Hydrogen Solar of Guilford, England, and Altair Nanotechnologies are building a hydrogen-generation system that captures sunlight and uses the energy to break water molecules into hydrogen and oxygen. Caltech

University professor of chemistry Nathan Lewis, who is working with GE on hydrogen research, said integrated systems that convert solar energy photoelectrochemically are more efficient than splitting water through the more extensively researched electrolysis technique.

Automotive companies have also made major progress in the hydrogen fuel technology. On March 17, 1999, DaimlerChrysler unveiled its hydrogen, fuel cell powered concept car called the NECAR IV. It has a refueling range of 280 miles and can travel at 90 MPH. Honda in 2005 has improved the combine fuel economy rating by 18 percent, from 48 to 57 miles per kilogram of hydrogen (McCormick 10).

This improvement increased the range from 160 to 190 miles using their current stack technology. General Motors have also been using fuel cell-powered forklifts in their auto plant. The forklift uses a fuel cell power pack that includes a fuel cell power module, an ultracapacitor storage unit, hydrogen storage, thermal management and power electronic controls (Siuro 30). These fuel cells uses Hydrogenics' HyPM 10 Proton Exchange Membrane (PEM) with a compact size of only 83. 82 cm long x 101. 6 cm wide x 60.

96 cm high with a maximum system efficiency of 56%. Due to the growing public attention in hydrogen fuel and support of government to research and development, the commercially viable hydrogen –powered vehicles may be closer than what we think. Just like any new technology that has been introduced, the best early market applications for fuel cells are in the small but high value markets. From there, economies of scale and other drives expand the market. This drives further development, in turn expanding

markets. The automobile is one of the most difficult markets for the fuel cell and most likely will be one of the last major markets into which they will be introduced.

Since the supply of oil comes largely from middle-east, other countries will be driven to quickly develop alternative fuel such as hydrogen fuel for economic reasons. Depending on foreign countries for fuel will become an economic problem when the price of oil rises due to growing demands. These drives coupled with the push to develop clean air vehicles, hydrogen fuel will surely take an important role in the fuel of future. Currently, there are a couple dozen small and large companies manufacturing fuel cells.

However the opportunity for growth in this market is tremendous considering the large market targets from power plants to automobiles, to laptops or even to cell phones. There is, and will be competitive opportunities for manufacturing, integrating and deploying fuel cells and related equipment for decades to come. Efficiency, zero emissions, scalability, and durability make hydrogen fuel attractive. Support from the government, research from a large number of firms and the development of prototypes from automotive industries points to a positive direction for hydrogen fuel in the future.

Couple this with the economic reasons of being able to produce local renewable energy, there is a strong drive for everyone to produce economically viable hydrogen fuel. When problems regarding cheap mass production, storage, safety, and fuel tank size are solved, there is no doubt, hydrogen fuel will become the fuel of the future. References: " What is a Fuel

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