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The Hydrogen Fuel Cell Solution: Improving Air Quality and Ensuring Energy Independence

by

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Because it is a necessity of modern life for industrialized nations, petroleum is one of the world's most sought-after natural resources. According to a February 2003 news release from the White House, America's energy security is threatened by our dependence on foreign oil because we currently import fifty-five percent of the oil we consume. This figure is expected to grow to sixty-eight percent by 2025 (2).

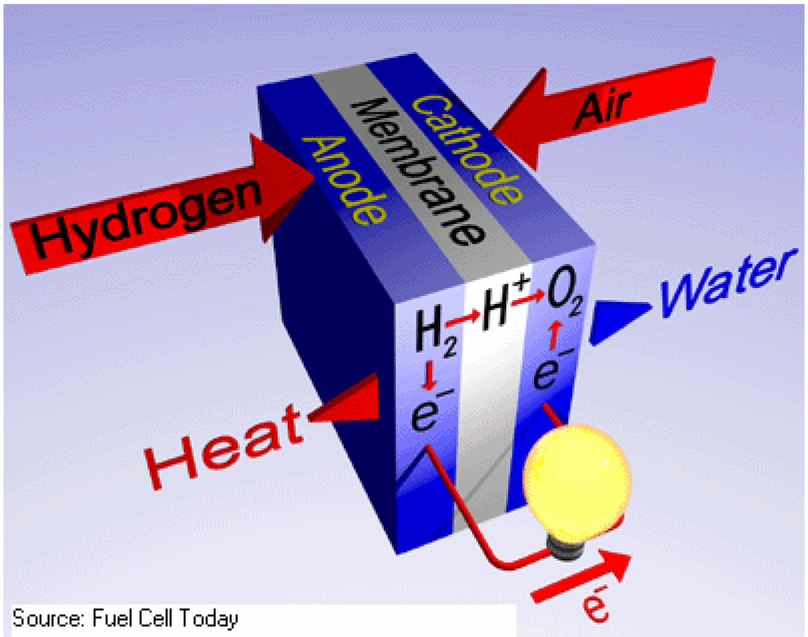
Any threat or action by an oil-producing country to reduce the supply of oil to the United States produces enormous anxiety. When the United States depends on a country for its oil, U.S. policies and relations tend toward making sure that Americans will be able to obtain oil from that country. According to the U.S. Department of State's Bureau of Near Eastern Affairs, Saudi Arabia has "possession of the world's largest reserves of oil [which] make its friendship important to the United States" (6). Therefore, countries with vast amounts of oil have tremendous power and influence in the world.

Some experts such as Colin Campbell believe that most of the world's oil and gas have already been discovered and that production will soon decline. In his 2002 research, Campbell states that the supply of "oil, which provides about 40% of global energy needs, and about 90% of transport fuel, is set to start to decline within about ten years." Campbell insists that actions must be taken now to find alternative fuels (5). Other experts such as David Deming predicts that significant amounts of oil still have not been discovered nor placed into production. Deming believes that "the world contains enough petroleum resources to last at least until the year 2100" and that there is no immediate need to look for an alternative fuel (6). I believe that petroleum, like all resources, has a limited supply and that it is only a matter of time when the supply would be depleted. One of the signs of industrialization and modernization is the rise in consumption of petroleum. Global demand for oil is not going to decrease in the near future as many countries such as China and India are becoming more industrialized. The United States Energy Information Administration reports that China's petroleum consumption increased from approximately 1.7 million barrels per day in 1980 to 5 million barrels per day in 2001 (4). In the far future, there will be a shortage of petroleum oil. Before the supply is completely depleted however, the price of petroleum would be so high that people would be motivated to actively search for an alternative.

In addition to the dependence on foreign oil and the potential political problems this can cause, our use of petroleum creates other problems. As the number of cars on the road increase, there is increasing concern about air quality. According to the Environmental Protection Agency (EPA), "automobiles create more polluted air than any other source. Although technology has significantly reduced auto emissions, dramatic increases in the number of vehicle miles traveled have overwhelmed the advances" (Ozone 6). Burning gasoline creates harmful chemical waste products that include the greenhouse gases known as carbon dioxide, carbon monoxide, nitrogen oxides, and hydrocarbons. The American Council for an Energy-Efficient Economy estimates that the average car (driven 15,000 miles) creates over 20,000 pounds of pollutants each year (DeCicco and Kliesch 121). Rising levels of greenhouse gases in the atmosphere make agriculture, wildlife, and coastal areas vulnerable to the changes that global warming may bring (EPA Global Warming 1). Hydrocarbons and nitrogen oxides also form harmful ground level ozone that is hazardous to our lung tissue. In addition, carbon monoxide reduces oxygen delivery to the body's organs and tissues.

Vehicle emissions are subject to increasingly tough laws designed to reduce air pollution. For example, the EPA has continuously enforced the reduction of nitrogen oxides, which aggravate respiratory problems and form smog. For 2004, the EPA allows cars to produce only .07 grams per mile of nitrogen oxides, which is a 77% reduction from the standard in 1999 (Emission 3). However, this reduction in emissions allowed from cars does not significantly reduce pollution concerns.

Because there are environmental and economic concerns associated with fossil fuels, the world needs a clean, abundant, and economically attractive alternative source of energy. Hydrogen fuel cells is the most promising solution to the petroleum problem.



Hydrogen fuel cells have two major components: the fuel cell and the hydrogen fuel used to supply energy for the fuel cell. As a whole, a hydrogen fuel cell is an electrochemical energy conversion device that converts hydrogen fuel and oxygen from the air into water, producing electricity (power for the engine) and heat in the process. Based upon data from Fuel Cell 2000, a single fuel cell is usually one foot in length and width, a quarter of an inch in thickness, and weighs one-third of a pound (Transportation 1). The fuel cell is composed of a thin ion-conductive membrane with platinum catalysts on both sides. Hydrogen enters on one side and oxygen on the other side. Hydrogen and oxygen react together at the platinum catalyst to create electricity and water. The hydrogen fuel cell is also known as a PEM fuel cell, which stands for proton exchange membrane.

The amount of power produced by fuel cells depends on their size and pressure of the hydrogen supplied. According to the Department of Energy, a single fuel cell produces around one volt, barely enough electricity for even the smallest applications (Fuel Cell screen 4). To increase the amount of electricity generated, individual fuel cells are combined in series known as a fuel cell stack. A typical fuel cell stack may consist of hundreds of individual fuel cells.

Hydrogen does not occur freely in nature and exists in compound forms such as water (H_2O). Hydrogen could be obtained from heating natural gas (CH_4) and gasifying coal, but this method would not resolve the air pollution concern because natural gas and coal are both fossil fuels. Another method to obtain hydrogen is biomass gasification, but this method is too price sensitive due to the reliance of the availability and supply of agricultural wastes. The cleanest and most dependable method to obtain pure hydrogen is the process of electrolysis, which uses an electric current to split water into hydrogen and oxygen atoms. The higher the pressure of the hydrogen supplied to the fuel cells, the faster the electrochemical reaction occurs and provides electricity.

There are tremendous environmental and economic benefits if the United States uses hydrogen fuel cells as the source of energy for vehicles. The German automaker DaimlerChrysler publishes an environmental report every year, and in the 2003 report, Nobel Prize winner Hermann Scheer claims that there is an "ecological limit in terms of what the earth's ecosphere will withstand if we keep on burning all these fossil fuels" (24). The use of hydrogen fuel cells will dramatically reduce pollution and global warming. Hydrogen is chosen as the fuel to power fuel cells because it is the most abundant and simplest element in the universe. An atom of hydrogen has only one proton and one electron. Since hydrogen could be domestically produced, hydrogen fuel will also help ensure America's energy security. If the hydrogen fuel industry flourishes, this would benefit the domestic economy because we would no longer need to import petroleum oil. NASA also observes that one pound of hydrogen supplies three times the energy of a pound of gasoline (Rocks 1).

In the state of Maryland, many drivers are familiar with the Vehicle Emissions Inspection Program (VEIP). Vehicle owners usually receive a test notice in the mail every two years from the Motor Vehicle Administration stating that they are required by law to bring their car to a testing station. An inspector checks whether the car meets the emissions standards of Maryland. Cars that fail the emissions test must be repaired to pass a re-inspection. Not only do people have to pay to get their car tested, it is also very time consuming. But if they were driving a hydrogen fuel cell car, their car would not have to be tested because when pure hydrogen is used as a fuel, fuel cells emit only heat and water.

However, the technical and cost challenges that keep hydrogen fuel cells from being widely available must be overcome before the environmental and economic benefits can be received. The first technical challenge is to develop the technologies and infrastructure to store and to distribute hydrogen for use in fuel cell vehicles. After production, hydrogen is stored in either gaseous or liquid forms. Hydrogen gas is difficult to store because it must be stored in a heavy tank to keep the gas from expanding. When hydrogen is stored as a liquid, it must be kept at –235 degrees Celsius to stay liquid.

The second technical challenge involves the fuel cell. Most fuel cells are individually built by hand rather than by machinery, so no company currently has the ability to manufacture fuel cells in high volumes. To manufacture fuel cells in higher volumes, a structural change in labor will be needed because workers will need to be trained to acquire the new technical knowledge. Increases in the production of hydrogen fuel cells will gradually lower the need for labor in the gasoline-based engine industry while increasing the need for labor in the hydrogen fuel cell industry.

The cost challenge is to lower the high costs of hydrogen fuel cells so that they are more cost-effective for use in cars. According to General Motors, current fuel cell production costs are ten times the amount used for gasoline combustion engines (Truett 1). Fuel cells are expensive to produce because they are individually built by hand and because fuel cells require large amounts of precious metals. Platinum is usually used because it allows the fuel reaction to occur in an efficient manner. Scientists are currently trying to find ways to reduce the amount of precious metals needed for fuel cells.

Although there are safety concerns about the flammability of hydrogen fuel cells, NASA reports that it has been using hydrogen fuel cells to generate electricity on space missions since the 1960s. Today, not only do hydrogen fuel cells provide electricity on space shuttles, they also provide drinking water for the crew (Cool 1). In addition, the Department of Energy states that the U.S. hydrogen industry currently produces nine million tons of hydrogen per year primarily for use in chemicals production, and that hydrogen is not significantly more flammable than any other fuel in common use (Hydrogen 1). This mass production also signifies that there are informed and experienced hydrogen handlers. Safety issues of hydrogen for use in fuel cell cars will be addressed in the development process just as the concerns about the flammability of gasoline were addressed in its development.

Extensive research and development are required to overcome the technical and cost challenges before fuel cells can be commonly used in vehicles. President Bush proposed a total of $1.7 billion over the next five years to develop hydrogen-powered fuel cells, hydrogen infrastructure, and advanced automotive technologies (Office of the Press Secretary 1). Many automotive companies around the world such as General Motors, DaimlerChrysler, and Toyota are also currently conducting research and development through testing of hydrogen fuel cell cars on regular roads.

The Breakthrough Technologies Institute reports that General Motors has developed a fuel cell vehicle called HydroGen 3 that uses liquid hydrogen as fuel, has a maximum speed of 100 miles per hour, and a range of 250 miles without the need to refuel. FedEx Corporation in Tokyo, Japan currently uses it for its regular delivery routes (2). Hydrogen fuel cell cars and buses are tested today in limited geographical areas because hydrogen fuel stations are not widely available yet. Fuel Cells 2000 reports that there are currently seventeen hydrogen-fueling stations in the United States with the majority of them in California (Worldwide 1).

Since the U.S. government and the automotive industry are spending billions of dollars in the research and development process, this shows a strong belief in the necessity of an alternative fuel and the future potential of hydrogen fuel cell cars. The government and the automotive industry believe that they can make hydrogen fuel cells work safely and efficiently in cars.

An article from the Geographical journal predicts that hydrogen fuel cell vehicles will most likely be widely used in the public transportation sector before being widely used in the private sector. This gradual expansion is due to the fact that most public transportation vehicles "travel over a limited region and regularly return to a central location, allowing a single hydrogen filling station to service the entire fleet" (3). In an environmental report interview, Jeremy Rifkin, author of The Hydrogen Economy believes that a significant infrastructure for hydrogen will be established by 2020 (Daimler Chrysler 27). Hydrogen fuel stations would have to be widely available across the entire United States in order for consumers to be willing to purchase hydrogen fuel cell cars because consumers generally want mobility. Trillions of dollars will be necessary to build large production and storage facilities, and a network of hydrogen fuel pumps across the United States.

Despite the various expenses needed to make hydrogen fuel cell cars a mass commercialized product, I believe the benefits of improving air quality and ensuring energy independence are worth the costs. Hydrogen fuel cells have the potential to take the place of gasoline-based internal combustion engines in providing renewable and clean energy for all vehicles.

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