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Geography 346

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**Hydrogen Fuel in Japan**

Energy systems are required to satisfy what humans need and want, and to allow for industrial, social and economic development. Our current energy resources are unsustainable and have adverse environmental impacts such as acid rain and global climate change (Dincer & Rosen, 2010). In the future, our energy systems will need to be sustainable and renewable, efficient and cost effective, convenient and safe. There is an ever increasing demand for energy and the availability of raw materials to satisfy our fossil fuel economy. The Hydrogen Energy Center states that we must find an alternative energy source as oil, coal, and natural gas supplies are not renewable (2012). Because hydrogen produces high amounts of energy, yet as it emits almost no pollution it is quickly becoming an ever attractive alternative energy source (“Hydrogen Energy”, 2012). Motivated to create a hydrogen based society for the future, the Japanese Ministry of Economy, Trade and Industry (METI) has launched the Hydrogen Town Project in Fukuoka Prefecture (“Hydrogen Town Project under way in Japan with Pipeline network”*,* 2011).

Increased global use of hydrogen will only occur if the transition away from current fossil fuel dependent energy is convenient and cost comparative. In order to ease the transition towards a hydrogen based economy, there must be a readily available supply of cost-effective and reliable hydrogen (Smith, 2012). Safe and efficient storage of hydrogen must also be in existence. Hydrogen is the most structurally simple and plentiful element in the universe (“Hydrogen Energy”, 2012). Hydrogen does not occur naturally as a gas on the Earth, it is always combined with other elements. This bountiful energy source can be found in organic compounds, or hydrocarbons that make up many fuels such as gasoline, natural gas, methanol, and propane (“Hydrogen Energy”, 2012). Hydrogen can also be created by separating hydrogen from hydrocarbons through the application of heat; a process known as reforming. Most hydrogen is made through this method using natural gas (“Hydrogen Energy”, 2012).

Hydrogen is currently used extensively as chemical feedstock, however over the next few years, the demand for hydrogen to be used as an energy carrier is expected to rise significantly (Smith, 2012). Hydrogen will likely be used in various forms of power generation and transportation. Hydrogen is very beneficial, it can be generated from a wide range of renewable energy sources, the use greatly reduces pollution and it can be produced locally from a number of sources. METI and private companies such as Nippon Oil understand the benefits associated with the use of this renewable energy source and believe that hydrogen is the fuel of the future (Ohnsman, 2011).

The Fukuoka Hydrogen Town model project commenced operation on October 11, 2008 in Maebaru City, Fukuoka Prefecture in southern Japan. The purpose of this project was to achieve a hydrogen energy society and create new industries in Fukuoka (Kimura & Tashiro, 2010). Fukuoka was chosen as the test prefecture for the following reasons. There are currently a wide range of research facilities and industries located in the prefecture. Fukuoka houses thirty-nine universities including twelve science and engineering universities and three technical junior colleges. Nissan, Tokota Motor and Daihastu Motor, all have their own production plants in the Prefecture with a production capacity of 1.5 million cars. Chemistry, rubber and fiber production plants are also located in the southern part of the prefecture. Fukuoka is located near many major cities in Asia within a few hours: 1.15 hr. flight to Seoul, 1.30 hr. flight to Tokyo, and Shanghai and 4.05 hr. flight to Beijing (Kimura & Tashiro, 2010). Five million people live in Fukuoka Prefecture, encompassing an area 4,976 km2. The Prefecture is quickly becoming an attractive place to live in; and Newsweek listed them at third place in “The top 10 fastest-growing cities in each of the world’s 10 most important economies (Kimura & Tashiro, 2010).

By installing hydrogen fuel cell systems into 150 homes through the use of the Ene Farm system, the model project will be the world’s largest demonstration of its kind (Iijima, 2009). Ene Farm is a residential fuel cell system commercialized in 2009 by Nippon Oil. Ene Farm is a system that produces electricity through an electrochemical reaction between oxygen and hydrogen (Kimura & Tashiro, 2010). The heat that is generated during the process can be used by the system as energy to boil water so that no energy is wasted during the process. The fuel cell system from Nippon Oil is designed with LP gas and generates electricity based on the reverse principle of the electrolysis of water. Hydrogen is extracted form LP gas energy and then implements a chemical reaction between hydrogen and oxygen from the air in the fuel cell stack to generate electricity (Kimura & Tashiro, 2010). The Ene Farm system is unique because it is able to learn the electricity and hot water usage patterns of a home so that the system is automatically operated in accordance with demand. The system is connected with a backup heat source that boils water, so there is never a concern about running out of hot water (Kimura & Tashiro, 2010).

There are many positive environmental impacts associated with the installation of Ene Farm. The system generates no nitrogen oxides or sulfur oxides which cause acid rain. It also has an energy efficiency level of 80% and is therefore able to reduce carbon dioxide emissions by as much as 30% when compared to conventional systems (Iijima, 2009). There are however, some financial drawbacks associated with this system. During its first year, the system cost 3.2 million yen, however costs are expected to decline over time as technology and availability improve (Kimura & Tshiro, 2010).

The model project was expected to run for four years in order to examine the energy saving effects of the system. The project is part of the Hydrogen Social Infrastructure Development Demonstration Project, which aims to establish a society fueled by hydrogen energy in the future. METI stated that hydrogen would be supplied through pipelines installed in urban areas, and hydrogen fuel cells would be operated across the community (“Hydrogen Town Project under way in Japan with Pipeline network”*,* 2011). The central government, and private companies such as Nippon Oil have backed the use of hydrogen as a sustainable fuel source. This project will enable Japan to have the world’s first hydrogen-powered town, and they will build the first “hydrogen corridor”, running from Fukuoka to Osaka and Tokyo (Arlidge, 2010). The project aims to be simple and self-sufficient. Electricity to power lights and heat water will be generated through a supply of hydrogen to each household.

A network of hydrogen filling stations will also be built so that divers can fill up their hydrogen fueled cars. There are currently two filling stations located in Fukuoka: Kyushu University Station and Kitakyushu Station (Kimura & Tashiro, 2010). Kyushu features an on-site station where H2 is produced from renewable energy. This station was built in Fukuoka city and allows for a filling pressure of 35 MPa. The Kitakyushu filling station is an off-site station constructed in Kitakyushu city. This station is one of three examples worldwide, where H2 is directly provided through pipelines from Steel Work (Kimura & Tashiro, 2010). Motivated to establish a hydrogen fueled society, Japan is working hard quickly produce hydrogen fuel-cell cars. Toyota Motor Corp. recently stated that by 2015 they are scheduled to sell hydrogen cars in California, Japan and Germany (Ohnsman, 2011). These areas were chosen initially because they “have the most developed fueling infrastructure” (Ohnsman, 2011). The cars are projected to retail for $50,000, which is a considerable price drop as a decade ago the vehicles were estimated to cost $1 million each. Vice president for research and product development of Toyota Motor Corporation, Takeshi Uchiyamada, has high expectations for the success of the hydrogen fuel-cell vehicles. Uchiyamada recently highlighted that “the cruising distance is almost comparable to conventional gasoline-energy cars” (Ohnsman, 2011).

There are many positive aspects towards the use of hydrogen as an alternative energy source. The Hydrogen Center outlines three benefits that address some of the concerns that suggest that the current energy economy is not sustainable (2012). The use of hydrogen greatly reduces pollution. When combined with oxygen, the only byproducts are water and heat; therefore no greenhouse gasses or other particulates are produced when using hydrogen fuel cells (Smith, 2012). Fossil fuel emissions significantly degrade global air quality. Carbon byproducts emitted from fossil fuel usage is also substantially changing the world's climate (Smith, 2012). Hydrogen can be produced locally from numerous sources. An advantage of using hydrogen is that it can be produced either centrally, and then distributed, or onsite where it will be used (Smith, 2012). This is very beneficial because currently used fossil fuels for energy are found in certain locations, and most of the people who consume fossil fuels don’t live where fuels are extracted (Smith, 2012).

Hydrogen gas can be produced from various renewable sources including methane, gasoline, biomass, coal or water (“Hydrogen Center”, 2012). Finally the Center states that if hydrogen is produced from water, than the production system will be sustainable. Renewable energy sources such as wind, hydro, solar and tidal can be used to power elecrolyzers to produce hydrogen from water. By using renewable energy sources this system is therefore sustainable and nonpolluting.

Arlidge writes that Nippon Steel, Japan’s biggest steelmaker, produces hydrogen that is normally burnt as waste. Because of the Hydrogen Town Project, it is able to recycle that hydrogen and pipe it to homes in Fukuoka and to filling stations in Kitakyushu City (2010). Residents that have converted their homes, find that they are saving money and protecting the environment. Japanese resident Yosuke Ito is happy that heat in his house is generated from hydrogen as he “save(s) thousands of yen a year, and we don’t pollute as much” (Arlidge, 2010). His fuel bills have dropped by 10%, and Nippon Oil states that in the future fuel savings will increase as hydrogen technology improves.

Unfortunately some skeptics argue that there are environmental drawbacks concerning the use of hydrogen energy. Some scientists say that the use of hydrogen energy could lead to “greater destruction of the ozone layer that protects earth from cancer-causing ultraviolet rays (Hebert, 2003). Because hydrogen travels skyward, they believe that increased use could almost triple hydrogen molecules, which would go into the stratosphere, where it would oxidize and form water (Hebert, 2003). Increased water would result in a cooling of the lower stratosphere and the disturbance of ozone chemistry that could deplete the ozone as much as 8 percent (Hebert, 2003).

Some argue that it is not feasible to serve all of our current energy needs with hydrogen energy. Ulf Bossel of the European Fuel Cell Forum, explains that when using wind electricity to generate hydrogen, only one quarter of the energy generated by the wind turbine is eventually used to move a car. The rest is lost during transport and energy conversion (Grinsven, 2006). As an example to prove why he believes that hydrogen is not a feasible energy source, he says that “to serve all planes at Frankfurt airport with hydrogen, we need 25 power plants of one gigawatt and all of Frankfurt's current water consumption" (Grinsven, 2006).

Presently the manner in which energy resources are used is considered to be unsustainable. There are many adverse environmental impacts associated with the use of nonrenewable energy. Some examples include global climate change, ozone depletion and acid rain. Dincer and Rosen note that current fossil fuel use threatens global stability. They also point out that “sustainable energy is ... considered a key requirement for sustainable development” (Dincer & Rosen, 2011). Hydrogen energy is considered to be a favorable alternative for a few reasons. Hydrogen is a renewable energy source, it does not contribute to environmental problems through harmful emissions or impacts and it is very efficient. For societies seeking a sustainable alternative to non-renewable energy resources, hydrogen fuel cell systems can play a significant role. Japan is motivated to establish a hydrogen fueled economy in the future and through support from the Japanese Ministry of Economy, Trade and Industry (METI), the nation has launched the Hydrogen Town Project.

 

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