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A study of hydrogen as an alternative fuel

I. Vinoth Kanna and Pallavi Paturu

Department of Mechanical Engineering, Vel Tech Rangarajan Dr. Sagunthala R & D Institute of Science and Technology, Chennai, India

ABSTRACT

As oil prices increase, the interest in alternative fuels increases. This is evidenced by demonstration programmes and commitments by states such as India. The concern of the air quality in many areas around the world makes finding solutions more urgent. As the price of oil increases, alternate fuels become more ruthless. Major questions remain to be answered on which fuel or fuels will emerge and to what extent alternative sources will replace gasoline as the main product of crude oil. A combination of available alternative fuels will evolve with the most likely choices affected by a number of technical, political and market factors. In order to allow a wider application of alternative fuels, a number of obstacles have to be overcome. These include economic, technological, and infrastructural issues. In the past, gasoline has been plentiful and has had a significant price advantage compared to other fuels. This could change quickly and alternative fuels would need to become more commonplace. One of the alternatives involves the more widespread use of biomass-produced fuels. In this paper describes that hydrogen as an alternative fuel. Hydrogen powered fuel cells could have wide applications, replacing batteries in many portable application, vehicle and using hydrogen for home electrical needs.

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1. Introduction

During the 1920s, the catalytic synthesis of methanol was commercialised in Germany. Even before that, methane was distilled from wood. This pyrolysis of wood is a relatively inefficient process. Ethanol saw several periods of popularity in the last century, especially during the world wars when petroleum became limited. In more recent decades, the use of alcohol fuels has seen rapid development.

The worldwide use of MTBE occurred quickly. The first MTBE plant was built in Italy in 1973, and its use then spread through Europe. By 1980, the installed capacity in Europe was almost 90 million gallons per year, which grew to over 300 million gallons per year by the end of 1990. In the United States MTBE, production began about 1980 and reached more than a billion gallons by 1987.

Due to high prices, air quality, and greenhouse gases alternative fuels started high demand after the oil crisis in the 1970s.

If alternative fuels are to be more widely used, changes must take place both in fuel infrastructure, storage and engine technology. Infrastructural changes will improve the availability of alternative fuels. This can be done by modification of existing filling stations and by establishing a distribution system that is as efficient as the current gasoline system.

Technological changes in the manufacture of power sources are required if they are to run on alternative fuels. It is likely that more power sources will move away from single-fuels to several fuels, which would compete (Vinoth Kanna, Devaraj, and Subramani, 2018).

This is done in many power plants today. Dual-fuel or flexible fuel are now used to some degree around the world.

2. Hydrogen sources

Most of the hydrogen used in the chemical and petroleum industry is manufactured from natural gas, which is a hydrocarbon molecule of four hydrogen atoms bonded to one carbon atom (Vinoth Kanna and Pinky 2018b). Gasoline is a hydrocarbon molecule that is made up of eighteen hydrogen atoms that are attached to a chain of eight carbon atoms. High temperature steam is used to separate the hydrogen from the carbon. If the cost of the natural gas is $4 per million British thermal units (MMBtu), the cost of the gaseous hydrogen will be about $10.00 per MMBtu. If the hydrogen is liquefied, an additional $8.00–$10.00 per MMBtu must be added to the cost of the gaseous hydrogen, making the cost of liquid hydrogen produced by this method about $20.00/MMBtu. If hydrogen is manufactured from water with electrolysis equipment, its cost is roughly equivalent to $5/MMBtu per 10 mills ($5/kWh/cent/kWh). Table 1 illustrates the major sources of global hydrogen production (Araya et al. 2016).

Hydrogen can also be manufactured from coal-gasification facilities at a cost that ranges from $8 to $12 per MMBtu, depending on the cost of coal and the method used to gasify it. But, making hydrogen from non-renewable fossil fuels does not solve the problem of diminishing resources or the environmental problems.

Most of the easy-to-get oil has already been found, and increasingly, exploration efforts have to drill in areas that are more difficult. Many areas have been closed to drilling in the United States. At some point, in the future, it may take more energy to extract the remaining fossil fuels than the energy they contain.

CONTACT I. Vinoth Kanna vinothkanna.research@gmail.com

Table 1. Global hydrogen production.

Origin	Percent
Natural gas	48
Oil	30
Coal	18
Electrolysis	4

Hydrogen can also be produced from resources that are renewable, such as the direct and indirect sources of solar energy; this includes the large quantities of agricultural wastes, sewage, paper and other biomass materials that have been accumulating in landfills (Vinoth Kanna, Vasudevan, and Subramani 2018).

Generating hydrogen from such waste materials may turn out to be one of the least expensive methods of producing hydrogen since this resource is quite extensive. It has been estimated that in the U.S., roughly 14 quads of the annual 64 quad total energy requirement could be met from renewable biomass sources, which is about 20% of our total energy needs.

Sewage in vast quantities of billions of gallons per day could be re- cycled to produce a renewable source of hydrogen. This can be accomplished either by utilising the non-photosynthetic bacteria that live in the digestive tracts and wastes of humans and other animals, or by pyrolysis gasification methods. Advanced sewage treatment systems could turn the billions of gallons of raw sewage that is being dumped into rivers and oceans into relatively low-cost hydrogen.

Although high-temperature nuclear-fusion reactors may someday be practical as renewable sources of energy for hydrogen production, they are probably many years away. Typically, over 100 million °F temperatures are required for nuclear fusion to occur and this technology, while under development, is not expected to be commercially viable in the near future.

3. Fuel cell generators

Fuel cells can be used to generate electricity, heat, and hydrogen. Fuel Cell Energy uses this technique in its molten carbonate fuel cell. Some solid oxide fuel cell (SOFC) companies are developing similar products.

Fuel cells running on natural gas typically use about three of the four hydrogen atoms in methane (CH_4) for power generation. The remaining hydrogen goes into the flue gas or stack effluent with differing amounts of CO_2, CO, and water vapour, depending on the type of fuel cell. The flue gas is sometimes vented to the atmosphere but it can be combusted for heat and used for reforming (University of Washington).

Hydrogen can be separated from the flue gas at low cost in high-temperature fuel cells. A SOFC system may be able to cogenerate hydrogen for about $3.00 per kg. This may be a little more expensive than gasoline or it might even match gasoline. Since these fuel cells could be part of the fueling station, there would be no need for a hydrogen delivery infrastructure. This requires fuel cells to achieve important technical and economic goals and overcome the barriers to utilisation (Vinoth Kanna, Vasudevan, and Subramani 2018).

Coal is another source of hydrogen. The coal is gasified and the impurities are removed so the hydrogen can be recovered. This results in significant emissions of CO_2.

4. Biomass potential

Developing biomass energy can provide economic, political, social and environmental advantages. The energy potential of biomass has been estimated at almost 42 quadrillion Buts which is about 1/2 of the total energy consumption in the United States. Biomass provides the U.S. with about the same amount of energy as the nuclear industry. Biomass can provide substitutes for fossil fuels as well as electricity and heat. Its resource base is varied. Arid land, wetlands, forest, and agricultural lands can provide a variety of plants and organic matter for biomass feedstock (Romm 2004).

Converting waste products to energy lowers disposal costs and pro- vides cost savings in purchasing energy supplies. Profitability can be improved by using waste to create energy. The sugar industry converts bagasse to energy and sells excess power. Biomass facilities often require less construction time, capital, and financing than many conventional plants.

In the Northeast alone, biomass accounts for over $1 billion in the economy and almost 100,000 jobs. Biomass production offers crop alternatives and the potential for increased income to farmers. Fields that are not used in winter can produce biomass, and varying crops in the same fields can help protect soil quality.

Biomass energy offers an increased supply with a positive environmental impact. If grown on a sustainable basis, it causes no net increase in carbon dioxide and the use of alcohol fuels reduces carbon monoxide emissions. Biomass is renewable as long as it is grown on a sustainable basis.

Although the feedstocks are widespread, they must be used locally since their bulk makes it costly to transport the feedstocks. Many available biomass feedstocks have a high moisture content, which lowers their heat value. Preprocessing can help, but adds to the cost (Devaraj et al. 2017). There are also some biomass conversion technologies that are only marginally beneficial and this keeps them from being cost-competitive (National Family Health Service). Table 2 shows the major sources of biomass utilisation in the United States.

5. The future for biomass

Government R&D funding for biomass increased slightly by 1990, but had decreased more than 75% from 1980 to 1989. The U.S. Department of Energy projected in 1989 that biomass could potentially become the world's largest single energy source if intervention to protect the climate takes place (Tu, Apfel, and Stimming 2006).

France has been experimenting with short-rotation forestry on more than 400 hectares of land. Northern Ireland is conducting similar experiments (Al-Baghdadi 2003). India has expanded its network of biogas digesters, which supplies compost to farmers and power to local communities. Finland provides almost 20% of its energy needs from biomass is working to increase this to 35% through using forest and peat feedstocks. Exotic fuels

Table 2. Utilisation of biomass resources in the U.S. (Study pinpoints renewables in U.S. energy).

Wood and wood waste (industrial/commercial)	50%
Wood (residential space heating)	35%
MSW, agricultural wastes, landfill gas and biogas, alcohol fuels	15%

such as those derived from algae may also be used but these still need more development. Other areas that need development include microorganisms for anaerobic digesters, genetic engineering for superior microbes, yeasts, and fungi, catalytic processing of lignins to liquid fuels and advanced fermentation techniques (Ramenskiy 2015).

Increased use of MSW as a fuel is also expected with the United States currently producing over 200 million tons of garbage each year. MSW offers a large, growing resource, even after recyclables are removed (Kale and Kulkarni 2011).

While it may be theoretically possible to replace the use of fossil fuels around the world with biomass energy, it is more likely, that biomass will take on a more important role as one of our energy sources.

The road to hydrogen vehicles and a hydrogen fueling delivery system may take many paths. Today, it may seem unlikely that market forces alone will result in the installation of thousands of hydrogen fueling stations spread uniformly across the country. But, this is exactly what happened with our present oil economy. Gasoline was originally available in small amounts often from hand pumps. As demand for gasoline for automobiles grew, so did fuel outlets.

An examination of efforts by the federal government to promote alter- native fuel vehicles in the 1990s illustrates the lack of interest in alternative fuels when gasoline is widely available. In 1992, the United States passed the Energy Policy Act. One goal was to reduce the amount of petroleum used for transportation by promoting the use of alternative fuels in cars and light trucks. These fuels included natural gas, methanol, ethanol, propane, electricity, and biodiesel. Alternative fuel vehicles (AFVs) can operate on these fuels and many are dual fueled also running on gasoline.

Another goal was to have alternative fuels replace at least 10% of petroleum fuels in 2000 and at least 30% in 2010. Part of the new vehicles bought for state and federal government fleets, as well as alternative fuel providers, must be AFVs. The Department of Energy (DOE) was to encourage

AFVs in several ways, including partnerships with city governments and others. This work went to the Office of Energy Efficiency and Renewable Energy. The initial efforts were reported in a 2000 report by the General Accounting Office (GAO).

By 1999, some 1 million AFVs were in use which is less than 0.5% of all vehicles. In 1998, alternative fuels used by AFVs replaced almost 335 million gallons of gasoline, about 0.3% of the year's total consumption. Almost 4 billion gallons of ethanol and methanol replaced gasoline that year in blended gasoline that was sold for standard gasoline engines.

The DOE has been developing clean energy technologies and promoting the use of more efficient lighting, motors, heating and cooling. As a result of these efforts and efforts by others, there have been savings by business and consumers of more than $30 billion in energy costs. Getting people to use alternative fuel vehicles has proven to be more difficult.

The GAO has stated that goals in the act for fuel replacement are not being met because alternative fuel vehicles have serious economic disadvantages compared to conventional gasoline engines. These include the relatively low price of gasoline, the lack of refueling stations for alternative fuels and the additional costs of these vehicles.

6. Hydrogen and internal combustion

Hydrogen powered internal combustion engines could promote infrastructure for fuel cell cars. An internal combustion engine (ICE) can burn hydrogen with a few inexpensive modifications. Automakers, including Ford and BMW, have been planning to introduce hydrogen ICE cars. They have the advantage over gasoline engines of very low emissions of urban air pollutants. However, there is the relatively high cost of today's hydrogen. Hydrogen engines are also about 25% more efficient than gasoline units. They are likely to have a smaller driving range due to the problem of storing large volumes of hydrogen on board (Vinoth kanna and Pinky 2018a).

Due to the high price of hydrogen, annual vehicle costs for mid-sized hydrogen vehicles could be one third higher than for current gasoline vehicles. This is slightly lower than the estimated annual costs for fuel cell vehicles, according to a report by the Arthur D. Little firm.

Because of the energy used in generating hydrogen from natural gas or electricity and the energy required to compress hydrogen for storage, the total energy use of a hydrogen internal combustion engine can be higher than a gasoline engine. One study of ten different alternative fuel vehicles found that burning hydrogen from natural gas had the lowest overall efficiency on a total energy consumed basis.

A report by the U.S. General Accounting Office (GAO) found that officials from federal agencies and state governments pointed to the lack of a refueling infrastructure more than any other reason to avoid alternative fuels (Eftekhari and Fang 2017).

7. Conclusion

Power crisis is the major problem which we facing now. In order to overcome this power crisis we have to come up some innovative alternative fuel. This paper describes about the hydrogen as an alternative fuel, which has zero emission and better efficiency. This paper describes verity of methods to produce hydrogen and efficient usage of hydrogen.

Disclosure statement

No potential conflict of interest was reported by the authors.

ORCID

I. Vinoth Kanna http://orcid.org/0000-0001-8194-8781

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