International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 9 Issue 7 ǁ 2021 ǁ PP. 45-48

Utilization of Hydrogen Created From Waste Products

Lakshay Raghav [1], Kartik Anand [2], Dr. J.P. Kesari [3]
[1,2] *Student, Delhi Technological University, New Delhi, India*
[3]*Associate Professor, Department of Mechanical Engineering, Delhi Technological University, New Delhi, India*

ABSTRACT
A large percentage of the world's population has no access to electricity. These individuals are majorly found in sub-Saharan Africa or developing Asia. Energy poverty is majorly found in rural communities, corresponding with a global distribution of extreme poverty. This problem exists over multiple levels. Around 38% of the global population live without clean cooking facilities and 34% of hospitals operate without main-grid electricity.[1] Traditional Hydrogen production technologies include steam reforming of natural gas, catalytic decomposition of natural gas, partial oxidizing heavy hydrocarbons, and gasification of coal. Certain areas are not connected to the electric power grids. The aim of this research is to develop a method which would make use of hydrogen to provide electricity to areas that are not connected to electric power grids.

Date of Submission: 10-07-2021 Date of acceptance: 26-07-2021

I. INTRODUCTION:

Waste-to-Hydrogen (WtH) is a specific part of the Energy from Waste (EfW) concept. It has an emphasis on hydrogen production from waste materials. The capability of hydrogen as a fuel is based on the properties and the interest from governments and industries for a clean fuel to take over fossil fuels.

Natural gas reforming has an efficiency of 70–75% while coal gasification has a relatively less efficiency of 45–65%[2]. All fossil fuel processes create high CO2 emissions. Other methods include thermochemical conversion of biomass, water via electrolysis, and biochemical methods involving bacteria and algae through anaerobic digestion and fermentation which can be used for low-carbon hydrogen production.

The research objective is to develop a method which would make use of hydrogen to provide electricity to areas that are not connected to electric power grids.

1.1 CURRENT GLOBAL SCENARIO

Presently, hydrogen is commonly produced by catalytic steam reforming of hydrocarbons which are and natural gas. However, processes using raw materials for the production of hydrogen, wastes and by-products have shown economic and environmental benefits. The governments of South Korea, France, South Korea and Switzerland have announced commitments to build a hydrogen economy. Japan has invested 348 million dollars in building hydrogen plants for the 2020 Summer Olympics in Tokyo. It is hoping to enjoy its legacy after the olympics. Germany launched the world's first hydrogen-powered trains last year. Two of these trains travel a 100 km route in northern Germany. A hydrogen - fuel -cell ferry is being built in California. [8]

Currently, the market for renewable hydrogen is dominated by water electrolysis; the electrochemical process involves splitting of water into hydrogen and oxygen. But it requires quantities of fresh water and renewable electricity at large scale to maintain the process green and practical, which limits it to countries like Iceland that have enough geothermal energy.[7]

In contrast, waste produced by humans is everywhere and it can be a very valuable material In remote areas without electricity. Hydrogen produced from waste can power homes and hospitals. Hydrogen is also a valuable chemical as it is useful for chemical reactions and processes in industry. It is the perfect reducing agent," says Zhiyong Ren, a chemist at Princeton University.

Ways2H Inc. and the shareholder and technical partner of it, Japan Blue Energy Co, announced the finalisation of a Tokyo plant that would convert sewage waste into renewable hydrogen fuel. It could be used for fuel cell mobility and power generation and fuel cell mobility. It demonstrates a new pathway for sustainable disposal of waste. [13]

The waste-to-hydrogen plant, located at the Sunamachi Water Reclamation Center, operates 1 ton of dried sewage sludge every day. It creates 40 to 50 kilograms of hydrogen every day, which would be enough to fuel 10 passenger vehicles or 25 fuel-cell e-bikes. [13]

Along with wastewater sludge, paper, plastics, municipal solid waste and other wastes would be refined. This is done by heating the waste at a high temperature and then converting it into a gas. Pure hydrogen is then obtained.[13]

1.2 SCENARIO IN INDIA

A large-scale bioreactor plant has been set up at IIT Kharagpur to produce the clean fuel, hydrogen.[3]

Hydrogen is categorised into three categories, namely, grey, blue and green based on the method of its extraction. There is a growing focus on increasing production of green and blue hydrogen. It is due to its no carbon emission and use of carbon offset technology. Along with this, several leading organizations are finding technologies which can convert bio and plastic waste into hydrogen [4]. This provides a huge scope for investment in this technology as it can combat India's twin problems - waste management and energy security.

The Finance Minister in the Union budget for 2020-21 recently announced the NHM. It's aim is to generate hydrogen from green renewable resources. The Ministry of New and Renewable Energy (MNRE) has also revealed that the draft regulations for NHM will be finalised in a short interval of time. It is believed that NHM would emphasize the generation of green hydrogen. It would enable green hydrogen's commercial use in the form of transportation fuel.[5] We will have to wait to see what lies ahead for us.

II. LITERATURE REVIEW

A lot of methods are used for the production of industrial hydrogen. As of the year 2020, the majority of hydrogen (~95%) is produced from fossil fuels by steam reforming of natural gas, coal gasification and partial oxidation of methane. Other techniques include the use of biomass gasification, water electrolysis, pyrolysis etc, which can be done using electricity obtained from solar power.

In the process of steam reforming, hydrogen production makes use of natural gas. This method is currently the cheapest source of industrial hydrogen. The process includes heating the gas to about 700–1100 °C in the presence of steam and a catalyst which is nickel. This reaction is endothermic so it breaks up the methane molecules and forms carbon monoxide (CO) and hydrogen (H_2). The carbon monoxide gas is then passed through steam over iron oxide or some other oxides. Then, it undergoes a water gas shift reaction which gives us further quantities of H2. [6]

2.1 RESEARCH OBJECTIVE

The main objective of this paper is to show how waste products can be used in rural areas to supply water and electricity. Biogas is a gas enriched with energy which is produced by anaerobic decomposition of biomass by anaerobic bacteria. Biogas is mainly composed

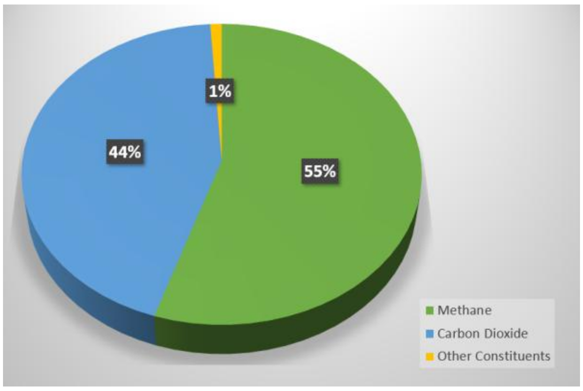


Figure: Distribution of components in biogas

of methane (CH_4) and carbon dioxide (CO2). The methane proportion in biogas may range from 40%–60%. The left proportion is mainly occupied with CO2 along with a small proportion of other components like water vapor and other gases. [8]

Biogas can be directly burned as a fuel. It can be used like natural gas after removing CO_2 and other gases. Treated biogas can be referred to as biomethane or renewable natural gas.[8]

III. METHODOLOGY

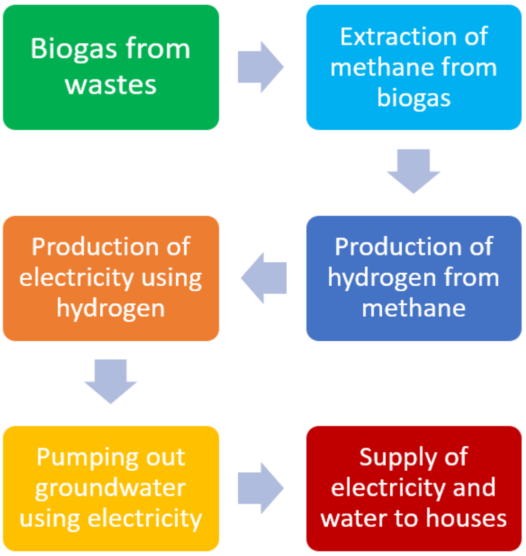
For our objective, we will need to accumulate all the waste materials from the rural area. This includes household wastes, animal wastes, human wastes, etc. The waste accumulated will then be left to produce biogas with the help of anaerobic bacteria which is present naturally in nature. The biogas is then extracted. Biogas is mainly divided into methane and carbon dioxide. The methane has to be separated from the CO_2 . This involves the use of membranes: filters that stop the methane and let the CO_2 pass through. A steam methane - reforming plant has to be set up to convert the methane into hydrogen. In this process, steam (H_2O) at a high temperature (700–1100 °C) reacts with methane (CH_4). It is an endothermic reaction with yields syngas.[10]

$$CH_4 + H_2O \rightarrow CO + 3\,H_2$$

In the second stage of this process, additional hydrogen is created by the relatively lower-temperature process; water gas shift reaction which is exothermic, achieved at about 360 °C:

$$CO + H_2O \rightarrow CO_2 + H_2$$

Actually, the oxygen (O) atom is removed from the additional water (steam). It's done for the oxidation of CO to CO_2. The oxidation process also acts as a provider of energy which maintains the reaction. Extra heat is required to drive this process. It is generally provided by burning some part of the methane. [11]



The resulting hydrogen can then be used to generate electricity with the help of hydrogen fuel cells. Hydrogen fuel cells produce electricity by combining hydrogen and oxygen atoms. The hydrogen reacts with oxygen across an electrochemical cell similar to that of a battery to produce electricity, water, and small amounts of heat. Large enough fuel cells would be able to provide electricity in places that are not connected to the electric power grids. They can also be utilized as a source for backup or emergency power in buildings. [14]

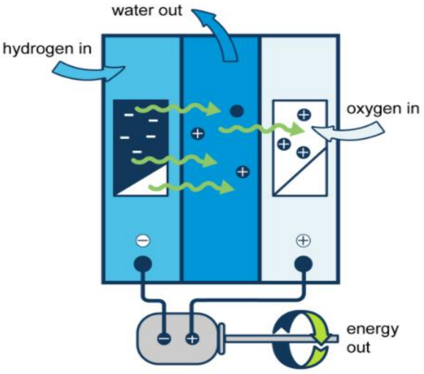


Figure : Hydrogen Fuel Cell

The electricity generated can be then used to pump out groundwater for use. After these processes, both electricity and water can be supplied to houses through individual supply lines.

3.1 ADVANTAGES

This technique will facilitate an independent supply of water and electricity in areas which are isolated. Complete utilization of waste products would be done. With this method, the people will get in the habit of throwing their waste in the compost which will also help the environment. The plant will also serve as a source of employment for the people of that area.

3.2 DRAWBACKS

This method may have high investment costs and high maintenance costs.

IV. CONCLUSION AND FUTURE PLANS

The greatest obstacle for hydrogen production, especially from renewable resources, is to provide hydrogen at lower prices. Hydrogen must be competitive with traditional fossil fuels and their technologies. This means that the cost of hydrogen—regardless of the production technology—must be less than $4/ gallon gasoline equivalent. [12] To reduce the overall cost of hydrogen, research is being focused on improving the efficiency and lifetime of hydrogen production technologies. Research is also going on to reduce the cost of maintenance, capital equipment and operations.

With development, straw may also be used to contribute to the production of hydrogen. This will reduce the air pollution caused by burning of straw and instead be a source of clean energy.

REFERENCES

[1]. Centre for Global Equality, https://centreforglobalequality.org/hydrogen-fuel
[2]. H.K. Ju, S. Badwal, S. Giddey A comprehensive review of carbon and hydrocarbon assisted water electrolysis for hydrogen production Appl Energy, 231 (September) (2018), pp. 502-533, 10.1016/j.apenergy.2018.09.125
[3]. https://economictimes.indiatimes.com/news/science/iit-developing-bio-hydrogen-fuel-from-waste/articleshow/46491568.cms
[4]. https://www.wastedive.com/news/opinion-waste-to-hydrogen-carbon-negative-future/578695
[5]. https://energy.economictimes.indiatimes.com/news/renewable/national-hydrogen-mission-leapfrogging-towards-indias-cleaner-future/80991679
[6]. Press, Roman J.; Santhanam, K. S. V.; Miri, Massoud J.; Bailey, Alla V.; Takacs, Gerald A. (2008). Introduction to hydrogen Technology. John Wiley & Sons. p. 249. ISBN 978-0-471-77985-8.
[7]. https://cen.acs.org/energy/hydrogen-power/Turning-organic-waste-hydrogen/97/i14
[8]. https://www.eia.gov/energyexplained/biomass/landfill-gas-and-biogas.php
[9]. https://cen.acs.org/articles/88/web/2010/11/Microbe-Powered-Device-Desalinates-Water.html?utm_source=InLine&utm_medium=InLine&utm_campaign=CEN
[10]. "HFCIT Hydrogen Production: Natural Gas Reforming". U.S. Department of Energy. 2008-12-15.
[11]. https://en.wikipedia.org/wiki/Hydrogen_production
[12]. Sunita Satyapal, https://www.energy.gov/eere/articles/hydrogen-clean-flexible-energy-carrier
[13]. https://www.waste360.com/waste-energy/ways2h-shareholder-japan-blue-energy-launches-tokyo-renewable-hydrogen-production
[14]. https://www.eia.gov/energyexplained/hydrogen/use-of-hydrogen.php