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Performance Studies on Hydrogen Production Device from Local Materials

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Abstract: *The country's widespread electricity challenges make it imperative to create alternative, less expensive methods of producing electricity that just require locally accessible minerals. In addition to sun energy, which is widely available, there is air and water. Water is one of the two readily available materials that may be divided into hydrogen and oxygen utilizing various processes. However, to remove hydrogen from the water, we will employ the electrolysis approach here with DC from the solar panel. A stainless steel equipped with a pair of rubber separators was employed forming the positive and negative sides of the stainless shape. To split the water into hydrogen and oxygen between the two plates, the wires were connected to power sources. The amount of hydrogen liberated is now measured against time to determine, the possibility of using it to generate electricity using a fuel cell. The result shows that the hydrogen generated is enough to power a small generator for electricity generation.*

Keywords: *Electricity, electrolysis, hydrogen, fuel cell, DC power, generator*

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I. INTRODUCTION

Fuel cell is one of the means of alternative energy generation in solving the energy supply challenges in the 21st century. Fuel cell enables clean, efficient production of electricity and heat from a range of primary energy sources. It makes use of hydrogen which is readily available and can be obtained from other means as its source of power (Felseghi *et al*. 2019). Forty-six percent of the electricity generated worldwide comes from the combustion of fossil fuels which has an environmental impact from their combustion (Burke and Stephens, 2018). Also, these resources will not last forever as the increasing population eats up the reserves of fossil fuels faster than ever (Burke and Stephens, 2018). Our future quality of life demands alternative solutions to meet the market needs as well as the production of reliable, high quality, and cheap energy, complimented with a reduction of environmentally harmful emissions, including greenhouse gases and toxic wastes. People must rely on renewable energy resources to achieve this goal (Burke and Stephens, 2018). Using a simple and inexpensive system such as electrolysis allows the splitting of water into its constituents (- hydrogen and oxygen), using direct current (DC) electric energy. The process satisfies the quest for high-quality hydrogen compared with other production forms (Felseghi *et al*. 2019).

A fuel cell is an electrochemical device, similar to a battery, that combines hydrogen and oxygen (which can come from the air) to produce electricity, heat, and water (Knauth, 2019). A fuel cell is composed of an anode (a negative electrode) and a cathode (a positive electrode), which are separated by a liquid or solid electrolyte. Generally, the electrodes are permeable or contain channels that distribute hydrogen or other substances and oxygen. The electrodes are frequently accompanied by catalysts, the most common being platinum or palladium (Barbir, 2012). In most fuel cells, hydrogen atoms enter the cell at the anode where their electrons are removed, producing direct current electricity, and positively charged hydrogen ions (Cations). Direct current can be converted to alternating current by an inverter. The electrons flow through an external circuit that extends from the anode to the cathode. The external circuit can include electric motors, lighting systems, or other electrical devices. The hydrogen ions travel through the electrolyte to the cathode where they recombine with the electrons and oxygen to produce water and heat (Mattey 2012). Fuel cells are endlessly rechargeable and productive, operate without combustion, have no moving parts, are nearly silent, and have an excellent safety record. Those recently developed for powering automobiles have an estimated life span of decades (Owusu, 2016). Fuel cells can be modular and scalable, many joined together are called a fuel-cell stack (Owusu, 2016). These characteristics allow the gradual addition of electrical capacity in response to increases in demand, as well as flexibility in the selection of sizes and locations for new stationary power plants. If stationary power plants are built at sites of electrical need, less of the electricity generated is lost during transmission and distribution (Mattey, 2012). Presently, the main planned uses of fuel cells are for the production of electricity at stationary power plants and to supply electricity for motors that move buses, trucks, and cars. Other contemplated applications include power for dwellings, trains, motorcycles, snowmobiles, watercraft, aircraft, and assorted electronic equipment (Andrews, 2012).

Hydrogen for fuel cells that power vehicles is derived from external sources and thereafter placed in onboard storage systems or is provided by an onboard "fuel reformer" that extracts hydrogen from accompanying supplies of methanol, gasoline, or other substances (Mattey, 2012). Pure hydrogen for the storage systems can be obtained from alcohols, naphtha, benzene, methane, propane, gasoline, and diesel fuel. Hydrogen is released when hydrocarbon-bearing materials in the presence of catalysts are subjected to pressurized steam (gasification) (IEA. 2017). It can also be obtained from water by electrolysis, where the electricity to brake water into hydrogen and oxygen could be supplied by hydroelectric generators, wind turbines, solar cells, or other producers of power. Hydrogen can also be generated by photo-electrochemical and photo-biological procedures (IEA 2017). In a few commercial fuel cells, gaseous mixtures of hydrogen and carbon dioxide are extracted from fossil fuels or biomass and used instead of pure hydrogen (Knauth, 2012).

II. MATERIALS AND METHODOLOGY

2.1 MATERIALS

- Perspex
- Stainless steel
- Rubber seal
- Threading rod
- Charging tube and hose
- Hydrogen and water container
- Washer and Nut

2.1.1 Perspex

Poly (methyl methacrylate) (PMMA), which is also known as Perspex, is a transparent thermoplastic often used in sheet form as a lightweight or shatter-resistant alternative to glass. It gives rigidity and support to the fuel cell, showing its inner structure through its transparency properties. A 10mm thickness of this material was used in the construction of this project, with a measurement of 4.5cm x 4.5cm for each of the Perspex used as shown in figure 1.

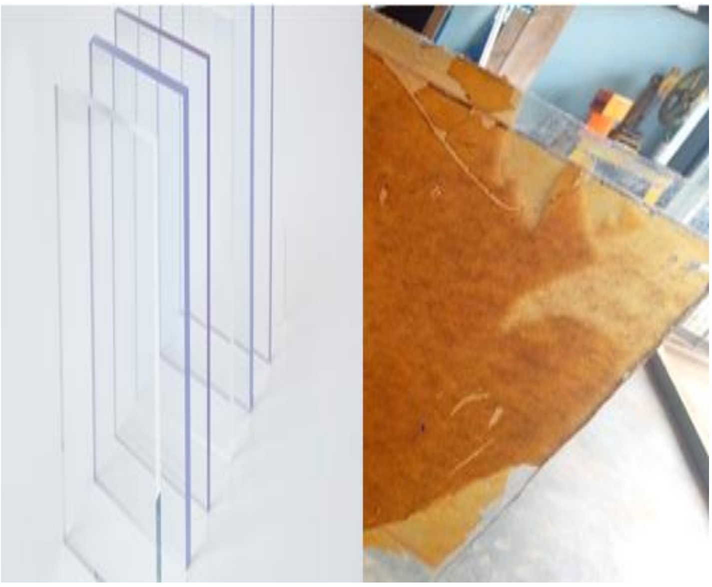

Figure 1: Snapshot of Perspex

i. Stainless steel

Stainless steel is a group of ferrous alloys that contain a minimum of approximately 11% chromium, a composition that prevents the iron from rusting and also provides heat-resistant properties (Harold, 2010) as shown in Figure 2. This project was constructed using 0.99 mm thickness of stainless steel and 3.48 cm length each.

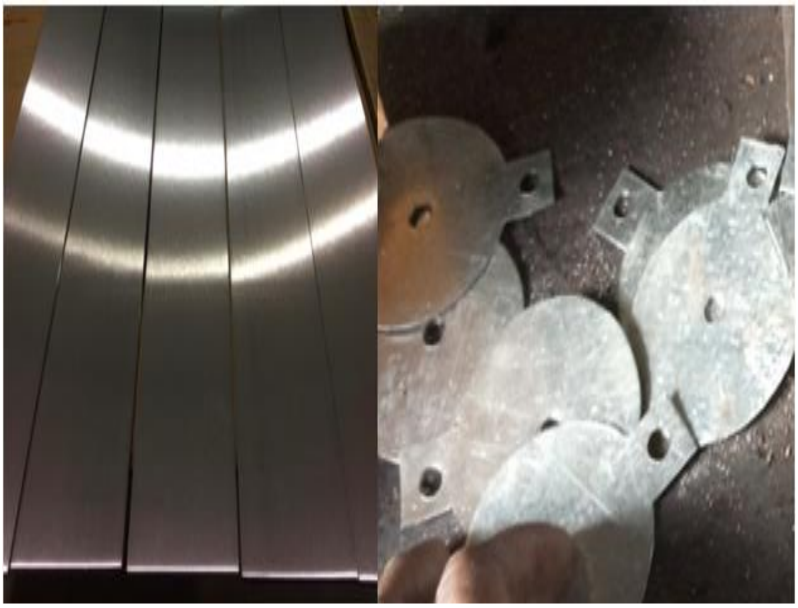

Figure 2: Snapshot of stainless steel

ii. Rubber seal

A Rubber seal is a device that is used to prevent the leakage of lubricating oil in mechanical equipment by closing the spaces between the moving and stationary components of the equipment.

Figure 3: Snapshot diagram of Rubber seal

iii. Coupling stud

A Coupling stud, also known as a stud, is a relatively long rod that is threaded to both ends; the thread may extend along the complete length of the rod. They are designed to be used to tension. It holds the complete stack of a fuel cell together as a single pack. It ranges from different sizes but and 8mm thickness of this material was used in this project having a length of 3.57cm holding the hydrogen generator from both ends.

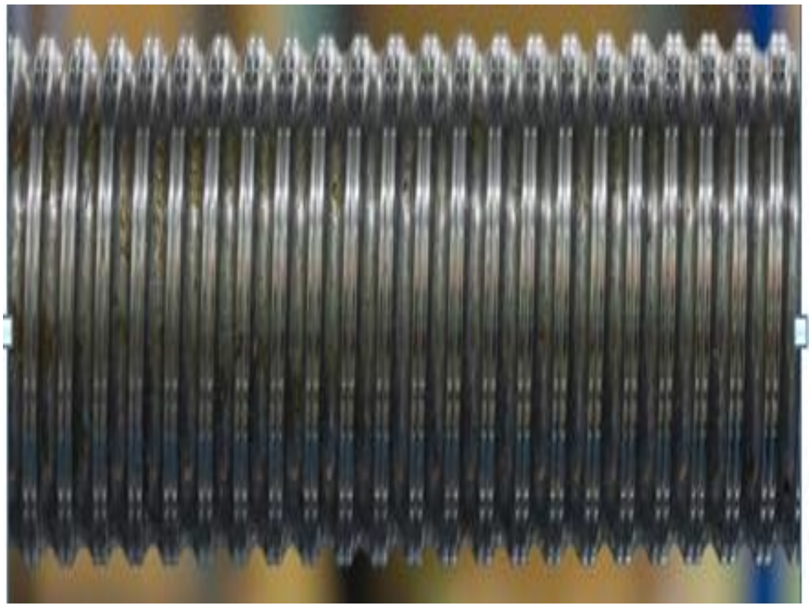

Figure 4: Snapshot diagram of Coupling stud

iv. Charging Verve

The charging verve is the inlet and the outlet openings connecting the charging hose to the water container. It is made of metallic material fabricated from a small round metal plumbing.

Figure 5: Snapshot of a charging Verve

v. Charging hose

A charging hose is a drainage pipe or channel that carries water from a predetermined source to the container. A quarter (¼) inch thickness of this material was used in the construction of this project.

Figure 6: Snapshot of a charging hose

vi. Hydrogen container

Hydrogen container is a key enabling technology for the advancement of hydrogen and fuel cell technologies in applications including stationary power, portable power, and transportation.

vii. Washer and nut

The washer is a machine component that is used in conjunction with a screw fastener such as a bolt and nut and that usually serves either to keep the screw from loosening or to distribute the load from the nut or bolt head over a larger area. It holds the threading rods from both ends to keep the Perspex closed together. A 13 mm nut was used to tighten this project.

Figure 7: Snapshot of washer and nut.

b. METHODS

The method used in this work is the process of electrolysis of water. Electrolysis of water is the process of using electricity to decompose water into oxygen and hydrogen gas. Hydrogen gas released in this way can be used as hydrogen fuel or remixed with oxygen t

o create oxy-hydrogen gas, which is used in welding and other applications. Sometimes, it is called water splitting.

A DC electrical power source is connected to two electrodes, or two plates (typically made from some inert metal such as platinum or iridium) which are placed in the water. Hydrogen will appear at the cathode (where electrons enter the water), and oxygen will appear at the anode. Assuming ideal faradaic efficiency, the amount of hydrogen generated is twice the amount of oxygen, and both are proportional to the total electrical charge conducted by the solution. However, in many cells competing side reactions occur, resulting in different products and less-than-ideal faradaic efficiency. Electrolysis of pure water requires excess energy in the form of

overpotential to overcome various activation barriers. Without the excess energy, the electrolysis of pure water occurs very slowly or not at all. This is in part due to the limited self-ionization of water. Pure water has an electrical conductivity of about one-millionth that of seawater. Many electrolytic cells may also lack the requisite electro-catalysts. The efficiency of electrolysis is increased through the addition of an electrolyte (such as a salt, an acid, or a base) and the use of electro-catalysts. The connections of the material are shown in Figure 8.
The process follows the equation for the separation of the water content into both hydrogen and oxygen.

Figure 8: Snapshot of Fuel cell hydrogen generator.

III. RESULT AND DISCUSSION

3.1 RESULT

The results obtained after the implementation of the hydrogen generator are carefully revealed in the following tables and graphs. These results have a close relationship with some of the results obtained by other researchers. However, there are slight differences due to differences in the quantity of the catalyst added to the water and materials used in the construction.

3.1.1 WATER WITH BAKING SODA

After filling the container with water containing baking soda and connecting the power supply with 12 volts, 7.2 Amps and repeating for 24 volts, 7.2 Amps for 5, 10, 20 30, 40, 50 and 60 minutes, the table below shows the results obtained.

Table 1: Volume of hydrogen gas generated at a given time interval for water with baking soda.

VOLTS (V)		TIME (SEC)
12	24	
RESULTS (CM^3)		
0.81	2.20	5
1.84	3.23	10
3.55	5.64	20
4.23	6.51	30
5.41	7.34	40
6.20	8.52	50
8.10	9.30	60

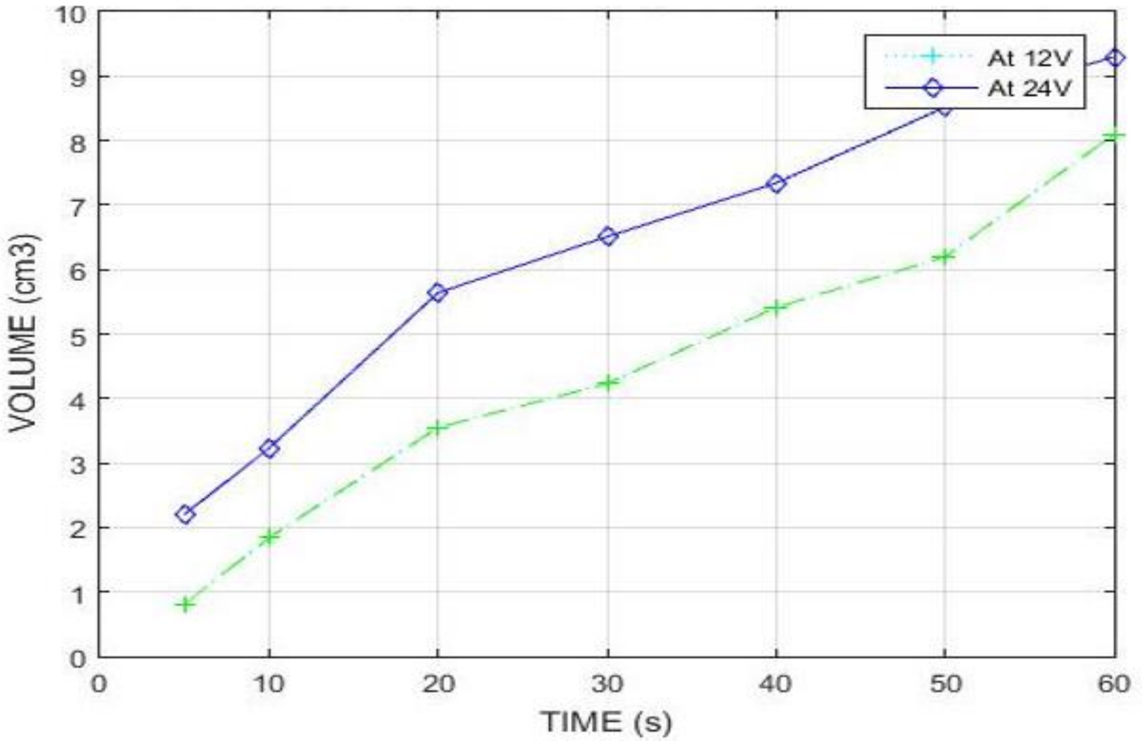

Figure 9: Graph showing the volume of hydrogen gas generated at a given time interval for water with baking soda.

3.1.2 WATER WITH SODIUM CHLORIDES

After filling the container with water containing sodium chloride and connecting the power supply of 12 volts, 7.2 Amps for 5, 10, 20 30, 40, 50, and 60 minutes, the step was repeated for 24 volts, 7.2mps. The table 2 shows the results obtained.

Table 2: Volume of hydrogen gas generated at a given time interval for water sodium chloride

VOLTS (V)		TIME (SEC)
12	24	
RESULTS (CM^3)		
2.20	3.11	5
3.52	4.40	10
4.13	6.35	20
5.0	7.30	30
6.25	8.55	40
7.53	10.2	50
9.82	12.3	60

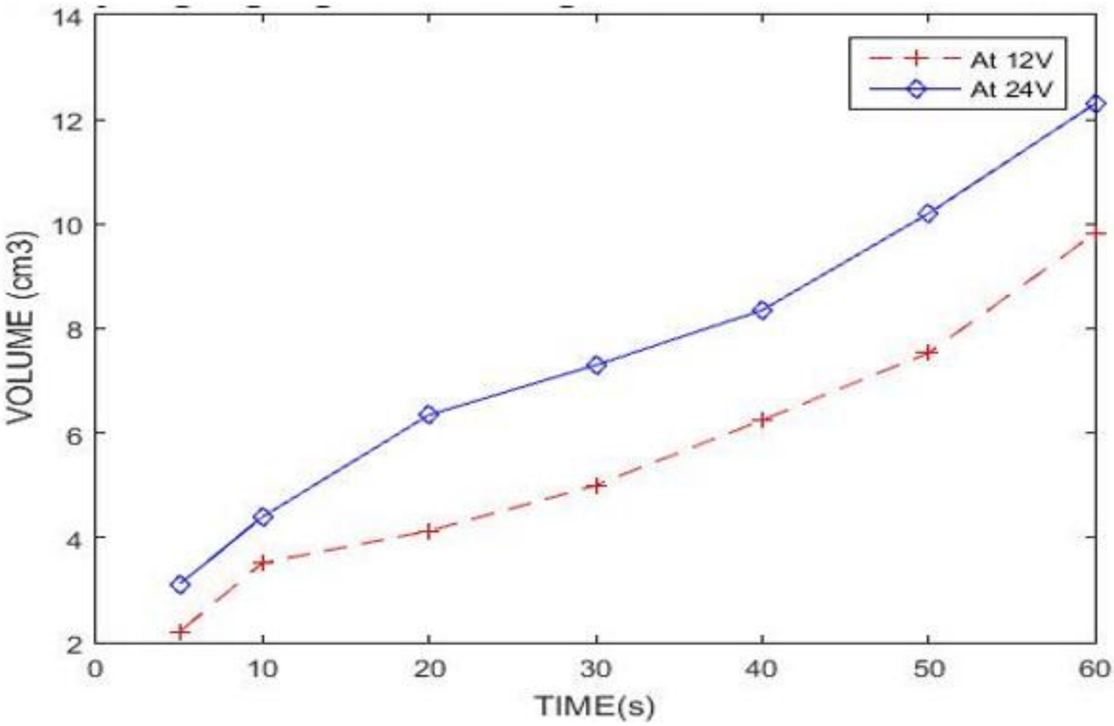

Figure 10: Graph showing the volume of hydrogen gas generated at a given time interval for water with sodium chloride**.**

3.1.3 NORMAL WATER

After filling the container with normal water and connecting the power supply of 12 volts, 7.2 Amps for 5, 10, 20, 30, 40, 50 and 60 minutes, the step was repeated for 24 volts, 7.2 Amps. Table 3 shows the results obtained.

Table 3: Volume of hydrogen gas generated at a given time interval for normal water.

VOLTS (V)		TIME (SEC)
12	24	
RESULTS (CM^3)		
0.30	0.80	5
0.54	2.90	10
1.23	4.80	20
1.60	5.80	30
2.25	6.50	40
2.82	7.30	50
3.40	7.91	60

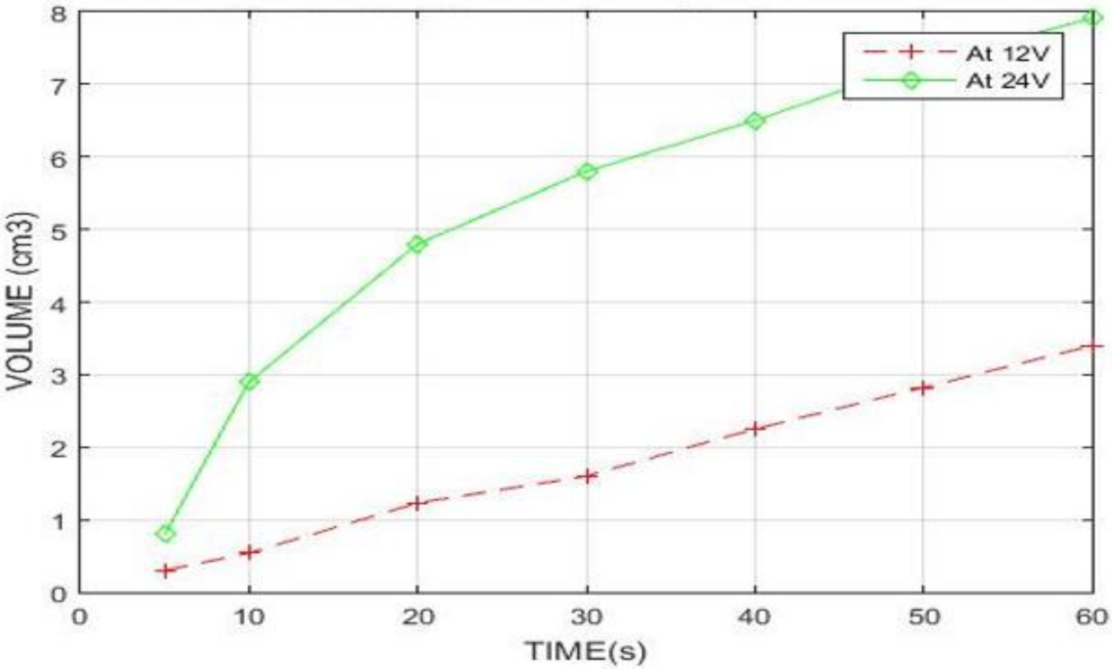

Figure 11; Graph showing the volume of hydrogen gas generated at a given time interval for normal water.

3.2 DISCUSSION

For electricity generation, hydrogen gas can be produced in four major ways. These techniques include electrolysis, biomass gasification, coal gasification, and the methane deforming method. Methane deformation is the most effective technique among the others according to study. However, because methane deformation releases carbon monoxide into the atmosphere, it is dangerous for the environment. Electrolysis is a low-power, zero-emission method with a working efficiency that is comparable to methane deformation.

Three different kinds of water were used: normal water, water containing sodium chlorides and water containing baking soda. The greatest amount of hydrogen was liberated by water containing sodium chloride, followed by water containing baking soda and normal water. This may be due to a catalyst present in water containing sodium chloride that quickens the pace at which hydrogen is produced during the reaction. On average, baking soda water was produced, which is superior to ordinary water. This might be due to the presence of sodium chlorides that speed up the reaction.

REFERENCE

[1]. Barbir F. (2012) PEM Fuel Cells: Theory and Practice imprint: Academic Press, ISBN: 9780123877109, Page 544.
[2]. Felseghi, Raluca Andreea et al. 2019. "Hydrogen Fuel Cell Technology for the Sustainable Future of Stationary Applications." *Energies* 12(23).
[3]. Burke, M.J.; Stephens, J.C. (2018) Political power and renewable energy futures: A critical review Energy Res. Soc. Sci., pp.35, 78–93.
[4]. Knauth P., Di Vona M.L. (2019) Solid State Proton Conductors: Properties and Applications in Fuel Cells, First Edition, John Wiley & Sons, Ltd., page 12.
[5]. Mattey, J. (2012) The Fuel Cell Industry Review; Fuel Cell Today Limited: Roystone, UK
[6]. Owusu, P.A.; Asumadu-Sarkodie, S. (2016) A review of renewable energy sources, sustainability issues, and climate change mitigation. Cogent Eng.,3, 1167990.
[7]. Andrews, J. Shabani B. (2012), Where Does Hydrogen Fit in a Sustainable Energy Economy? Procedia Eng. 49, pp. 15–25.
[8]. International Energy Agency (IEA) Hydrogen, Global Trends and Outlook for Hydrogen, December 2017.