Hydrogen and Oxygen Production from Solar panel Using Electrolyzer

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Abstract.

Now a day the utilization of renewable energy resources is raised to meet out the energy demand. The major drawback in renewable energy sources is discontinuous energy supply. Hence, to overcome the drawback, a proper energy storage system is required. Usually, the batteries are used. On using batteries, periodic maintenance is required and not appropriate for long-term storage. Therefore, for long-term usage, the excess energy can be stored in hydrogen gas form. For storing excess energy, as hydrogen gas an Electrolyzer method is used. During the conversion process, oxygen gas is produced as a by-product. In this paper, a buck converter is designed to step down the voltage. The output of the converter is given as input to the electrolyzer for the production of hydrogen and oxygen gas. This system is pollution less system.

Keywords. Solar PV system, Buck converter, Electrolyzer, Hydrogen gas, Oxygen gas.

1. INTRODUCTION

Energy is the prime source for socio-economic development of country [1]. The renewable resources have become the most vital field in research, based on availability of resources and it will reduce the impact of fossil fuels in the environment. These unconventional energy carriers are always obtaining the greater popularity in particular to the awareness of shortcomings of fossil fuels and its rise in price cost [5]. Among the non-conventional renewable resources, the energy produced from solar energy has become an affordably greater probable for the conversion of electric power [2].

A hybrid renewable energy system comprising of solar panel/wind turbine generator/biogas generator/fuel cell is investigated for both standalone and on-grid applications in [1]. An optimal configuration of the system is developed to meet the electricity demand for both economical and environmental point of view. A case study on electricity generation in South Australia State [3] by utilizing the stored hydrogen in large quantity and longtime storage applications are discussed. The storing the energy in battery and in the form of hybrid battery hydrogen storage systems are compared based on the development of technology and as well as on economical point. As a result, it is found that hybrid battery hydrogen system is costlier. Similarly in [4], the energy storing in battery and in the form of hydrogen are compared. It is

concluded that the combination of battery and hydrogen storage system has advantages of both the systems. Hybrid Renewable System with Fuel cell is investigated on techno-economic point of view for Bozcaada Island in Turkey [5]. The study concluded that this method is expensive and the cost per unit of electricity is $0.17/kWh. From these literature reviews, it is understood that the storing energy in hydrogen form is a more promising system for long term storage. In [6], an optimized off-grid solar PV/Fuel Cell/Diesel Generator power system is designed for a university building. In [7], a standalone hybrid solar/wind/Fuel Cell/battery energy source is constructed and experimentally verified for various environmental conditions.

From the literatures, it is found that the solar energy plays a major role in electrical energy generation system. The generated electrical energy from the solar panel is proportional to the intensity of sun light on the photovoltaic (PV) panel. In literature [8-11] presents the solar PV energy system combined with electrolyzer to produce hydrogen. The modeling and simulation of hydrogen production from solar panel is discussed [12]. The nominal analysis of hydrogen production from solar PV array is illustrated [13-14]. The analytical and experimental results of electrolyzer for hydrogen production with various temperature effect and flow rate are discussed [15]. In this paper, the hardware set up of hydrogen and oxygen production system is discussed in first section and the hydrogen production using electrolyzer from solar PV system is discussed in second section.

2. PROTOTYPE DESCRIPTION

The hydrogen and oxygen production system from solar PV system consists of solar panel, buck converter, electrolyzer and two separate tanks for storing hydrogen gas and oxygen gas. The block diagram to describe the prototype model of hydrogen and oxygen production system from solar PV system is shown in Figure 2.1.

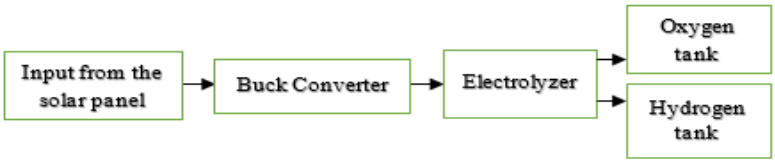

Figure 2.1. Block Diagram of Solar tracking system

2.1. Solar Panel

The light energy (photons) from the sun is flows on Photovoltaic modules to produce electrical energy. Mostly the module uses the wafer-based crystalline silicon cells or thin-film cells [2]. The cells are connected electrically in series with one another. Here 5W panel is used with 12 modules. PV modules are grouped in series to achieve maximum power voltage of 8.2 V. The open circuit voltage is 10 V and short circuit current as 0.29A.

2.2. Buck Converter

For the hydrogen and oxygen production from the electrolyzer, the electrical energy is required for conversion of gas. The DC voltage obtained from the solar panel is higher than the required voltage of electrolyzer. The required range of single cell electrolyzer is 1.5V – 3V. For that, a suitable buck converter is required. A Buck converter is a switching mode DC to DC electronic converter. It helps to transform the higher voltage level to the lower level voltage as required. Hence, it is also named as step down converter [11].

2.3. Electrolyzer

Electrolysis method can be used for hydrogen gas and oxygen gas production from the renewable resources. In the Electrolysis process, the electrical energy is used to segregate the water molecules as hydrogen and oxygen [8]. The electrolyzer composed of electrolyte, cathode and anode. In this paper, polymer electrolyte membrane (PEM) electrolyzer is used and the electrolyte is a solid plastic material placed in between the anode and cathode. At the anode side, the water entered and as a result of chemical reaction the oxygen and positively charged hydrogen ions (protons) are produced. Through the external circuit, the separated electron flow and the hydrogen ions passes through the electrolyte membrane (PEM) and reaches the cathode end. At the point, the hydrogen ions react with electrons from the external circuit and produce hydrogen gas. The reaction at anode and cathode end is expressed below [10],

Anode Reaction: $2H_2O \rightarrow O_2 + 4H^+ + 4e^-$

Cathode Reaction: $4H^+ + 4e^- \rightarrow 2H_2$

3. RESULT AND DISCUSSION

In this research work, a solar panel of 5W is used with a maximum output voltage of 8.2V, short circuit current as 0.29A. From the panel, 8.64 V is produced during the full sun rays falls on the panel. The output voltage of solar is converted to 3 V by using buck converter. Then the output of buck converter is given as input to the electrolyzer. The hardware setup of Solar PV panel with electrolyzer is shown in Figure 3.1.

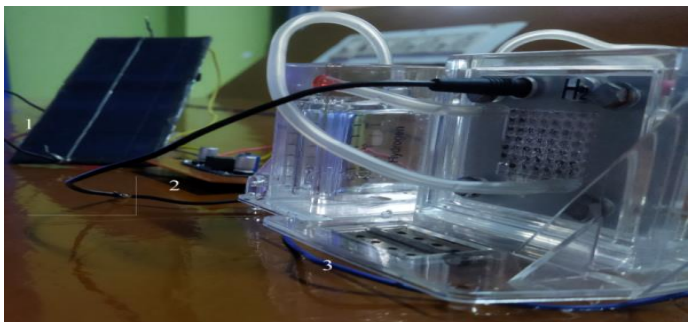

Figure 3.1. Hardware setup of Hydrogen and Oxygen production from solar PV panel using Electrolyzer 1. Solar PV panel 2. Buck Converter 3. Electrolyzer

The electrolysis process is used for separating the water molecules as hydrogen and oxygen. In the electrolyzer, the electrodes are connected to an external electric field and thus the electrons travel across the electrically conductive electrode at that time the protons travel through the PEM membrane. On supplying electrical energy, the water split into hydrogen ion and oxygen separately stored in two tanks with the capacity of 24ml and 12ml tanks respectively as shown in Figure 3.2.

Figure 3.2. Hydrogen and oxygen gas are separately stored in two tanks

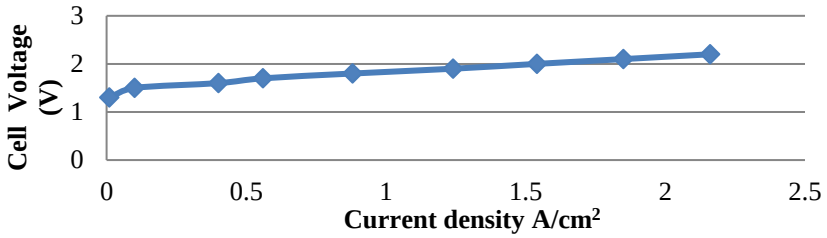

Figure 3.3. V-I characteristics of Electrolyzer

The Electrolyzer cell voltage and current density characteristic is shown in Figure 3.3. The increase in input voltage level, the corresponding production level of hydrogen and oxygen gas is also increased. The flow rate of both the hydrogen gas and oxygen gas is shown in Figure 3.4.

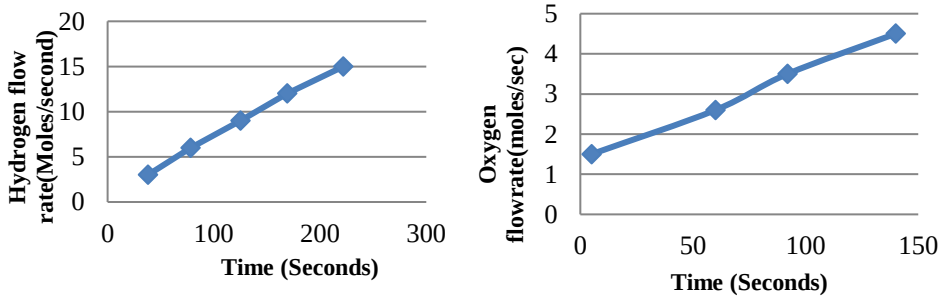

Figure 3.4. Hydrogen and oxygen flow rate from electrolyzer

4. CONCLUSION

This paper presents the hardware setup of hydrogen production and oxygen production from solar panel using electrolyzer. The energy generated in solar PV is reduced using buck converter as required for single cell PEM electrolyzer. An electrochemical reaction takes place during electrolysis process and split the water molecules as hydrogen and oxygen gas. The two gases are stored separately in 24ml and 12ml tank. The generated hydrogen gas can be used in fuel cell for production of electrical energy and oxygen can be used for medical purpose. This system saves the excess energy of solar without any lose and rectify the intermittent problems of renewable energy resources.

5. FUTURE SCOPE

In future, the fuels are going to be rare factor. At that time, the hydrogen gas plays an important role in the automobiles. This method of hydrogen production can be automated with suitable controller as a future work.

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