ISSN No:-2456-2165

The Implementation of Photovoltaic System and DC-DC Converter for the Production Process of Hydrogen Gas through Electrolysis

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Abstract:- Hydrogen gas can be produced through the electrolysis process using Hoffman Voltameter method which breaks the water compound into its constituent elements of hydrogen (H_2) and oxygen (O_2) using DC electric current source. DC electrical current source which is used, it can be derived from the photovoltaic modules (PV) by reason of its use without emitting carbon dioxide or require fossil fuels. This research will be observed the production of hydrogen (H_2) with a direct connect system design of the photovoltaic modules (PV) to the electrolysis reactor and converter system designs that use Direct Current to Direct Current (DC-DC). DC-DC converters are designed in this study is used to change the voltage and current of photovoltaic modules (PV) and batteries to increase the production of hydrogen (H_2). The research result shows that the direct testing of a hydrogen production of 41,3 ml/h with a light intensity of 30 140 lux, a temperature of 33,8 ° C, the voltage of 19,22 V and a current of 86,8 mA. The amount of light intensity and temperature of the surface of the photovoltaic modules (PV) measured in this study is directly proportional to the power output of photovoltaic modules (PV) and the production of hydrogen gas. DC-DC converters are designed to increase the production of hydrogen gas for the fourth time on testing using the battery as a storage medium. The most optimal production of hydrogen gas occurs in testing using the system design of the photovoltaic modules (PV) using a DC-DC converter 53,1 ml.

Keywords:- *Electrolysis, Hydrogen, DC-DC Converter, solar cell.*

I. INTRODUCTION

The development of renewable energy (EBT), which includes natural resources for energy and electricity has been mentioned in some regulations. Alternative energy, which is still widely studied one of which is energy of hydrogen gas (H_2). In accordance with Law 30/2007 on energy mentioned that hydrogen is a source of new energy with new technologies to be mastered as an economic base. Hydrogen is the most abundant element with a percentage of about 75% of the total mass of the universe. Hydrogen also includes a reactive gas that is used as an alternative energy because hydrogen readily soluble in a variety of compounds. With this, the hydrogen to consider its use as an alternative energy in view of its ability to become an alternative energy [1].

Two-thirds part of the earth consists of water (H_2O) is a great potential for obtaining hydrogen in the water because there is the content of hydrogen gas. One way to get hydrogen gas from water is by splitting water into its constituent elements, namely oxygen (O_2) and hydrogen (H_2). Hydrogen is projected by many countries will be more fuel efficient and more environmentally friendly because it has a combustion rate of 75% better than gasoline. One way to split water into hydrogen gas is in the process of electrolysis. Electrolysis is a chemical process that converts electrical energy into chemical energy by way of an electrolytic dissociation into ions in the electrode in the presence of an electric current. Electrolysis process can be done by mixing a catalyst, because when the catalyst is added to water, the electrical conductivity of the electrolyte solution is increased so as to accelerate the reaction [2].

Based on these things considered, further research related to the production of hydrogen gas, this research will be discussed on the implementation of photovoltaic systems and DC-DC converters for the production of hydrogen gas through electrolysis process. The use of photovoltaic systems in this study due to the power generation system does not emit carbon dioxide or need fossil fuels [3].

In this study used a series of additional tools including the charge controller is used as a control voltage and output current of solar cells to get to the battery and to the load. Besides the use of the battery so that the energy electricity were produced by solar cells can be deposited and the results of storage can be used in the production process of hydrogen gas through electrolysis process at any time without being influenced by the factors of the solar cell itself, and the DC-DC converter which serves to increase the input voltage H2 gas production in order to obtain larger. This research was conducted with the system design using DC-DC converters and system design without the use of a DCDC converter, it is intended that the obtained effect of the use of the H_2 gas production.

The benefits of hydrogen itself after forming them for transportation fuels, fuel cells, industries that use hydrogen and others. However, in this study is limited to the formation process was not until it's usage.

ISSN No:-2456-2165

II. METHODOLOGY

To achieve the objectives of this study required several stages so that the research process can run well and structured. Stages of research can be described in Figure 3 a flow diagram of the study.

The study flow diagram explaining an outline of how the research is done, step - step what to do and what kind of testing conducted in the study. In this study used a power source is a DC source output of a solar module panels 50 WP. An additional suite of tools that charger controller, battery with a capacity of 45 Ah, DC-DC converters and electrolysis reactor. Reactor Hoffman Voltameter electrolysis method in which require electrodes and electrolyte. Electrodes used 304 stainless steel, while the electrolyte used is H2SO4. The electrodes and the electrolyte used in the electrolysis reactor.

In this test, there are several steps being taken, namely:

- Tests using the system without a DC-DC converter. This test is done to see the results of production of hydrogen gas directly from source Hoffman Voltameter with electricity generated by the solar cell from 07:00 to 18:00 o'clock pm with a light intensity parameter and the external temperature.
- Tests using a DC-DC converter system. This test was conducted to see the effect of the DC-DC converter to the production of hydrogen gas. In this system, there are several series of additional tools prior to Hoffman Voltameter namely charger controller, batteryand DC-DC converters. This system is used so that the production of hydrogen gas can be done at any time without being influenced by factors that affect the output of solar cells. Tests were also conducted with variable voltage and current values varied set of converters to find the optimum point of hydrogen gas production in this study.

A. The Design of DC-DC Converter

DC-DC converter is a circuit which has been designed with the use of electronic components are transistors, diodes, capacitors, resistors, IC NE555, IC LM7812, transformer and PCBs, which the DC-DC converter will serve to increase the output of solar cells or batteries 12V 45AH in this study.

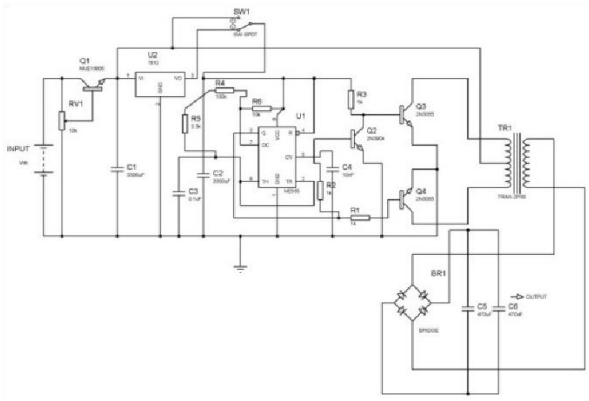

Fig. 1: The design of DC-DC Converter

It can be seen that a series of DC-DC converters to be designed using several electronic components such as C2, C3, and C4 are capacitors which serves as a store electrical charges that are used to help supply the electrical charge that will be supplied to the IC NE555 in order to meet the configuration of the IC is needed to meet the configuration that produces an oscillation that is producing the signal box that will help the process of a series of 2N3055 transistors, the C1 is used to keep the input voltagesupplied from the source,

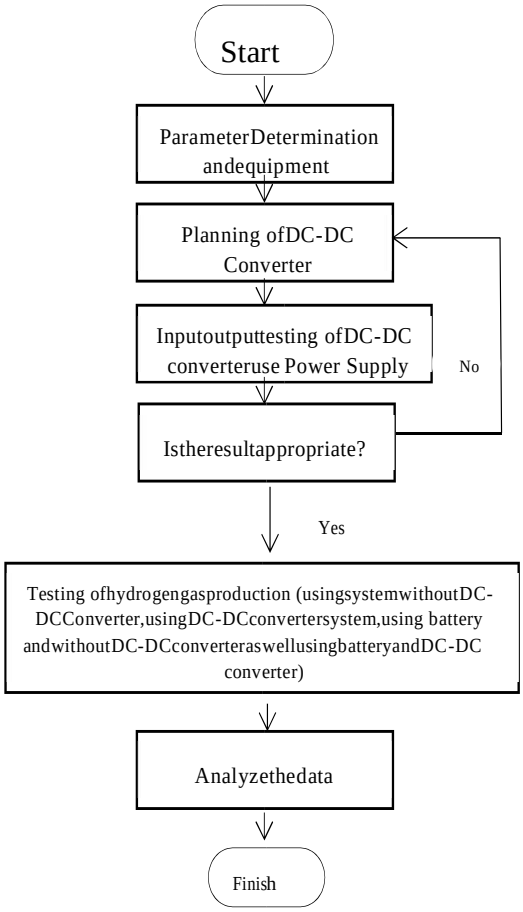

Fig. 2: Research Flowchart

IC 7812 is a regulator IC which is used to regulate the input voltage in order to achieve an input voltage of 12 V so that the IC NE555 no excess voltage is determined by the IC NE555 datasheet itself. NE555 IC as an oscillator used to trigger Q3 and Q4 is used as a switch in order to get the AC signal is needed for transformer CT. The use of resistors 1, 2 and 3 in order to avoid overcurrent will destroy the transistor. Diode bridge which is used to rectify the output transformer, and the use of C5 and C6 as a filter on the output side.

B. Hydrogen Formation Process

Electrolysis reactor that has been filled with 230 ml of an electrolyte solution of distilled water (water) and the catalyst has been determined concentration was then closed the valve top to inhibit gas is formed out of the reactor. Stoppers on the bottom of the electrolysis reactor is used to prevent leakage

ISSN No:-2456-2165

of electrolyte solution and connecting the reactor with a series of tools that are used.

In this study, after the reactor was treated gas will be formed within the reactor. The calculation of the amount of gas that is formed by reading the manual reduction of water volume at t = 0 s to t = 15 minutes to 1 hour.

After the reactor was treated gas will be formed within the reactor. The calculation of the amount of gas that is formed by reading the manual reduction of water volume at t = 0 s to t = 15 minutes to 1 hour. The production of hydrogen can be calculated theoretically using the following equation:

$$G = \frac{ME \times i \times t}{96500} \quad (2)$$

$$n = \frac{G}{Mr} \quad (3)$$

$$Volume = n \times V_{STP} \quad (4)$$

G = mass of substance (g)
i = current (A)
t = time (seconds)
ME = the relative atomic mass divided by oxidation numbers
n = number of moles (mol)
Mr = relative molecular mass
VSTP = volume of gas in a state of STP (22.4 l)

III. RESULT AND DISCUSSION

A. *The Result of Testing DC-DC Converter*

Tests were carried out on a DC-DC converter has been designed to look at the magnitude of the output value is generated by using a power supply as an input to the DC-DC converter is shown in Figure 3 as follows.

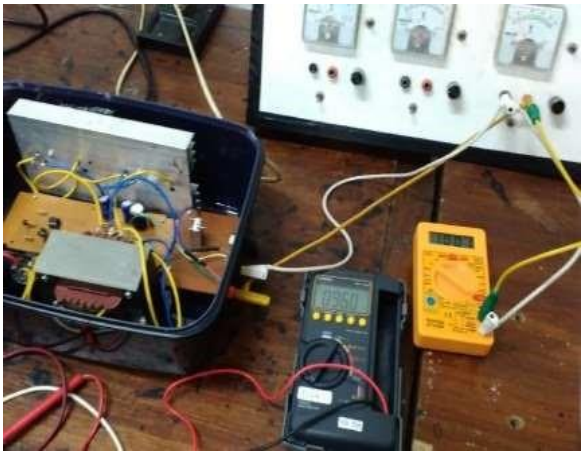

Fig. 3: The Tests DC-DC Converter Using Power Supply

Figure 3 shows the tests performed on the DC-DC converter has been designed to look at the magnitude of the output value is generated by using a power supply as an input to the DC-DC converter. This experiment was carried out as many as six times the input voltage power supply used for 10V, 11V, 12V, 13V, 14V and 15V and the load of 1,586 KΩ generate the data shown in Figure 4.

Based on Figure 4 graphs can be seen the difference of each output voltage of the source, namely when the source voltage gain of 86V 10V, 11V when the source voltage gain of 94,5V, when the source voltage of 12V increase 103,5V, when the source voltage 13V increase of 112 , 7V, 14V when the source voltage gain of 121V and 15V when the source voltage is increased by 130,3V.

Based on Figure 7 observations that have been made using a digital oscilloscope generated an oscillating signal box to drive the AC transformer, a frequency of45.0097 Hz and aduty cycle of 47.0% this suggests that the DC-DC converter circuit that has been designed to work well.

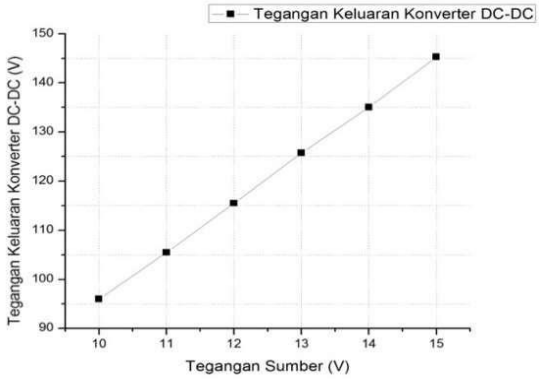

Fig. 4: Graph Test Result DC-DC Converter with Power Supply

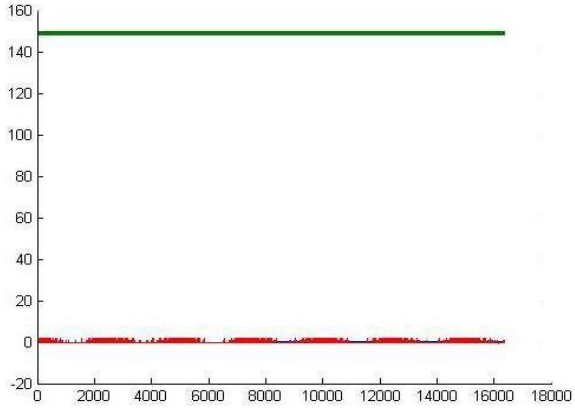

Fig. 5: Output Signal of DC-DC Converter

Figure 8 shows the output signal of the DC-DC converter that has been designed so that a measurable signal DC is not visible it is because output ripple DC-DC converter is installed which serves as a filter capacitor on the output side. In Figure 8 the measured value of the output voltage of 148 V.

B. *The Testing of Hydrogen Gas Production*

a) The Testing Using System Without DC-DC Converter
This test is done to look at the production of hydrogen gas that is formed directly from the source of solar panels to the electrolysis reactor Hoffman voltameter. The hydrogen produced in the electrolysis process is calculated at the time t = 0 seconds to process t = 3600 seconds or 1 hour of 07:00 o'clock until 18.00 o'clock. Using an electrolyte solution used distilled water with a concentration of 1% sulfuric acid 230 ml and

ISSN No:-2456-2165

electrode SS 304. Here are the test results obtained from the test results using the system without a DC-DC converters for three days of observation.

The test results of hydrogen production Tuesday, 10 November 2015 may be graphics which are formed in one day during the 11 hours from 07: 00-18: 00 pm in Figure 6, 7, 8, 9 and 10 as follows.

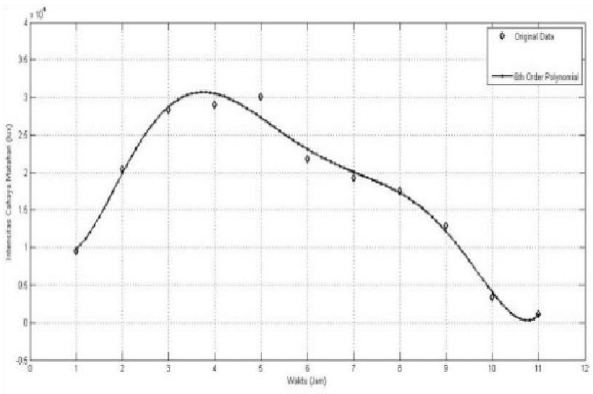

Fig. 6: Graph Sun Light Intensity Measured Against Time.

Based on Figure 6 can be seen that the graph of the results of regression measured light intensity for 11 hours collecting data from 07: 00-18: 00 pm. The data obtained show that the light intensity is highest at 11: 00-12: 00 pm that data retrieval fifth hour of 30 140 lux. The lowest point of the decline occurs when the light intensity of 1,119 lux at 18:00 pm that data retrieval eleventh hour.

Further measurements performed on the surface of the solar panel temperature for 11 hours in one day of data collection can be seen in the chart that is formed in Figure 10 as follows.

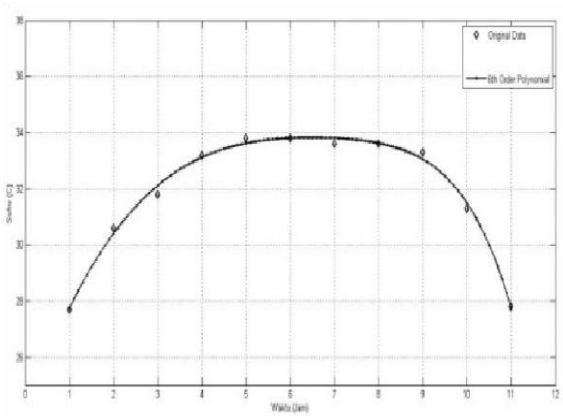

Fig. 7: The Graph of Surface Temperature Solar Panel Measured Against Time

Based on Figure 7 it can be seen that the results of the regression graph solar panel surface temperature measured over 11 hours of data collection. The data obtained show that the largest temperature is 33.8 ◦C in the fifth hour of data collection at 11: 00-12: 00 pm, after which it decreased again reached 27.8 ◦C at the eleventh hour.

Furthermore, to see the solar panel voltage were measured for 11 hours in one day of data collection can be seen in the chart formed in Figure 8 as follows.

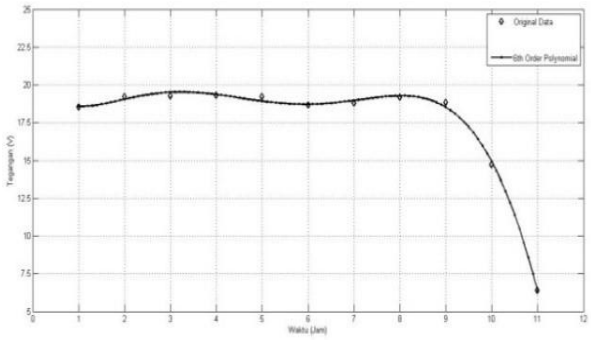

Fig. 8: The Graph of Output Voltage Solar Panel Measured Against Time

Based on Figure 8 it can be seen that the graph of the results of regression measurable voltage for 11 hours of data collection. The data obtained show that the increase and decrease in the measured voltage does not look great based on Figure 11 are from 07: 00-16: 00 pm this is because the solar panels are still in good conditionsolar radiation. The decline occurs when solar radiation begins to decrease at 16: 00-18: 00 pm from 18.84 V to 6.38 V.

Furthermore, to see the current measured solar panels for 11 hours in one day of data collection can be viewed graph form in Figure 9 as follows.

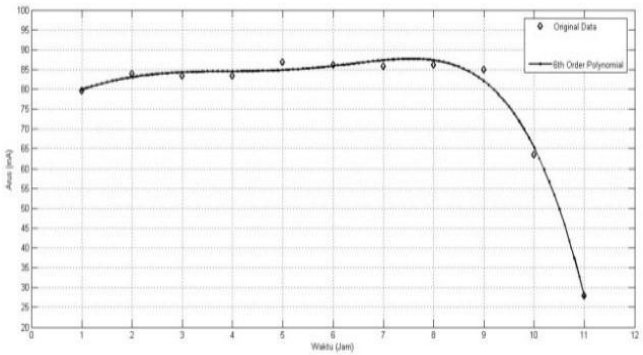

Fig. 9: The Graph of Output Currents Solar Panel Measured Against Time

Based on Figure 9 it can be seen that the current regression graph measurable results during the 11 hours of data collection. The data obtained show that the largest flows occur at 11: 00-12: 00 pm which is the fifth hour at the time of data collection at 86.8 mA. The increase and decrease in the measured current does not look great based on Figure 12 are from 07: 00-16: 00 pm this is because the solar panels are still in good condition solar radiation. The decline occurs when solar radiation begins to decrease at 16: 00-18: 00 pm from reaching 28.06 mA 84.98 mA.

After the measured voltage and current, voltage and current is used to process and produce H2 electrolysis gas, to see the production of H2 gas for 11 hours in one day of data collection can be seen in the chart formed in Figure 10 as follows.

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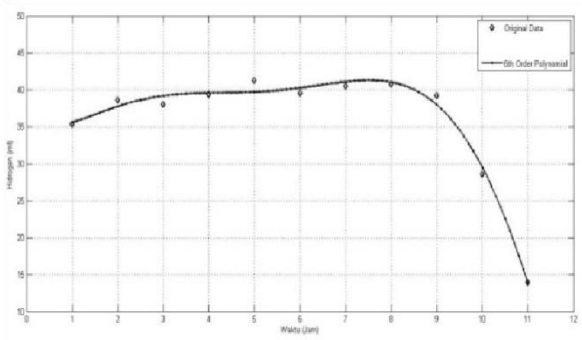

Fig. 10: The Graph of Hydrogen Gas Production Against Time

Based on Figure 10 it can be seen that the graph of hydrogen gas production regression results are measured every hour for 11 hours of data collection. The data obtained shows that the highest production of 41.3 ml. Lowest H2 production occurred at 17: 00-18: 00 pm or eleventh hour at the time of data collection that is equal to 14 ml.

From the test results using the system without DC-DC converters or directly from the solar panel to the electrolysis reactor as a whole can be seen that the production of hydrogen gas through electrolysis process is the highest occurred at 11:00 to 12:00 pm with the greatest production of 41.3 ml with light intensity sun at 30 140 lux, a temperature of 33.8 ° C, the voltage of 19.22 V and a current of 86.8 mA.

The overall relationship between the intensity of sunlight and the temperature is measured interplay, namely when the light intensity increases, the temperature also increased, while in some time there is a change that does not look the same from the raising and decline this is due to the observation that measured manually every 15 min measurements are still fluctuations and inaccuracies are perfectly in conjunction. The intensity of sunlight and the temperature is very influential on the output of solar panels so affect the production of hydrogen gas is formed, can be seen in the graph circuiting to the production of hydrogen gas is generally linear.

On testing with a system of solar panels directly to Hoffman Voltameter unstable production occurs due to factors

b) The Testing Using DC-DC Converter System
After testing without DC-DC converter or from solar panels directly to the electrolysis reactor has been done it could further testing hydrogen gas production from the solar panel to the DC-DC converter which is then connected to the electrolysis reactor Hoffman Voltameter.

This stage is the same as that performed on the stage of gas testing hydrogen production directly from solar panels to the electrolysis reactor Hoffman Voltameter, This is done to see yield comparison between them.

The test results can be seen in the graph of hydrogen production which is formed in one day during the 11 hours from 07: 00-18: 00 pm in Figure 11, 12, 13, 14 and 15 as follows.

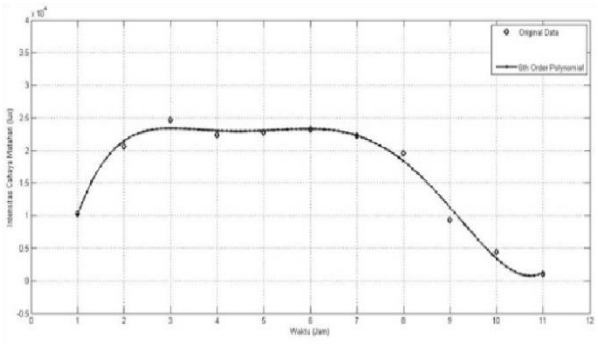

Fig. 11: The Graphs of Sun Light Intensity Measured Against Time.

Based on Figure 11 it can be seen that the graph of the results of regression measured light intensity for 11 hours collecting data from 07: 00-18: 00 pm. The data obtained show that the measured light intensity fluctuates depend on the environmental conditions at the time of data collection.

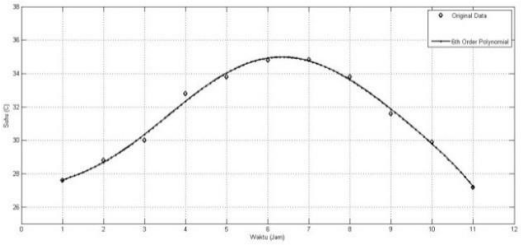

Fig. 12: The Graph of Surface Temperature of Solar Panel Measured Against Time.

Based on Figure 12 it can be seen that the results of the regression graph solar panel surface temperature measured over 11 hours of data collection. The data obtained show that the largest temperature ◦C 34.84 which is the data retrieval seventh hour, after which there is a decrease of 27.2 ◦C back at the eleven hour.

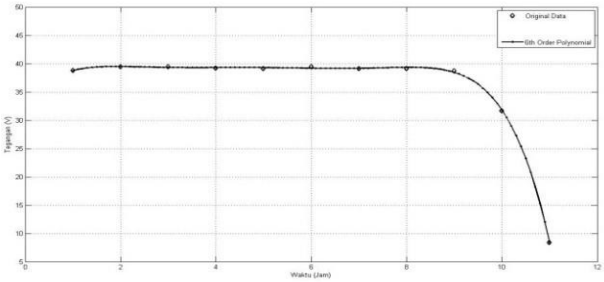

Fig. 13: The Graph of Output Voltage Solar Panel Measured Against Time

Based on Figure 13 it can be seen that the graph of the results of regression measurable voltage for 11 hours of data collection. The data obtained show that the increase and decrease in the measured voltage does not look great by Figure 4.22 is from 07: 00-16: 00 pm this is because the solar panels are still in good condition solar radiation. The decline

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occurs when solar radiation begins to decrease at 16: 00-18: 00 pm from 38.72 V to 8.44 V.

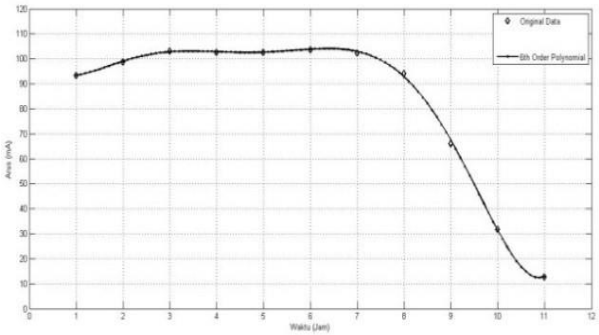

Fig. 14: The Graph of Output Currents Solar Panel Measured Against Time

Based on Figure 14 it can be seen that the current regression graph measurable results during the 11 hours of data collection. The data obtained show that the largest flows occur at 12: 00-13: 00 pm which is the fifth hour at the time of data retrieval of 103.74 mA. The increase and decrease in the measured current does not look great based on Figure 17 are from 07: 00-16: 00 pm this is because the solar panels are still in good condition solar radiation. The decline occurs when solar radiation begins to decrease at 16: 00-18: 00 pm from reaching 12.82 mA 65.98 mA.

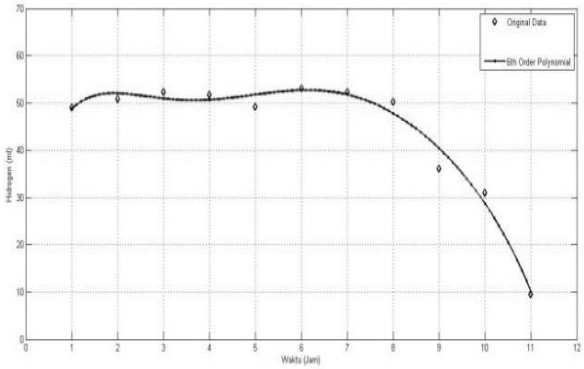

Fig. 15: The Graph of Hydrogen Gas Production Against Time

Based on Figure 18 it can be seen that the graph of hydrogen gas production regression results are measured every hour for 11 hours of data collection. The data obtained shows that the highest production of 53.1 ml. Lowest H2 production occurred at 17: 00-18: 00 pm or eleventh hour at the time of data collection in the amount of 9.6 ml.

In testing the production of hydrogen from solar panels to the DC-DC converter which is then connected to the electrolysis reactor Hoffman voltameter seen that the highest production occurs in the light intensity of 23 280 lux, a temperature of 34.8 ° C, voltage of 39.47 V and a current of 103.74 mA. This shows that an increase of the use of a DC-DC converter has been designed, seen from previous data on testing directly from the solar panels to the electrolysis reactor Hoffman voltameter.

It can be seen that the data production has been made of solar cells directly without battery storage media or highly dependent on external environmental conditions and can not perform continuous production it is necessary to test to production using a battery.

c) Testing Using the Media Storage (Batteries) and Variation Output Voltage DC-DC Converter
This test is done to get the gas production of hydrogen using a battery storage media in order to perform continuous production without being influenced by external environmental conditions the received solar panels. The test is conducted in two stages which would then be compared to the results. First test gas production of hydrogen using electrolysis reactor directly to a battery and the second battery to the DC-DC converter output further into the electrolysis reactor.

The results of the testing of hydrogen gas production of hot-swappable battery and system using a DC-DC converter with a voltage variation can be shown by Figure 16 as follows.

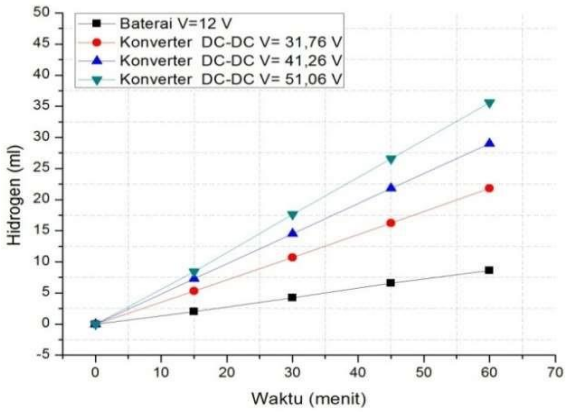

Fig. 16: The Graph of Hydrogen Production from Direct Battery and Varying Voltage Output DC-DC Converter

Figure 16 shows that the increased production of hydrogen can be regulated by a DC-DC converter source linearly over in a state of good operation. In data obtained in this test also obvious increase in the production of hydrogen from use DC-DC converters than the use of battery output source directly to the electrolysis reactor.

d) The Comparison of Hydrogen Gas Production for All Test
The production of hydrogen gas through electrolysis process in this research has been carried out with four kinds of tests are as follows:

- The test uses a system without a DC-DC converter (solar panels - electrolysis reactor Hoffman voltameter)
- Tests using a DC-DC converter system (solar panel - converter - electrolysis reactor Hoffman voltameter)
- Testing production of hydrogen gas using a storage medium (battery) and without a DC-DC converter

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- Testing production of hydrogen gas using a storage medium (battery) and a DC-DC converter.

Based on data from optimum hydrogen gas production from the four test has been obtained, it can be seen the comparison in Figure 17 as follows.

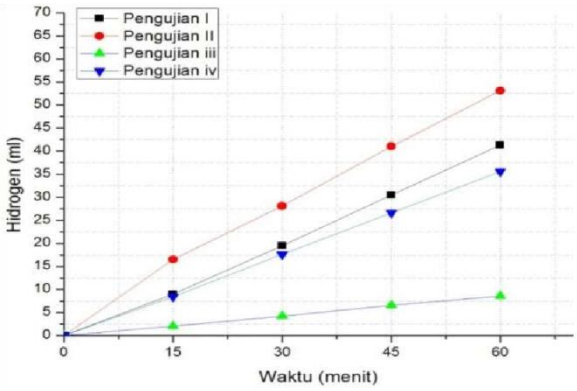

Fig. 17: The Comparison Graph of Hydrogen Gas Production for All Tests

Figure 17 graphs the production of hydrogen gas from the appointment of the four kinds of tests, the most optimum production occurs in the second test is test use of solar panels system design using DC-DC converter and the final output of the converter that has been upgraded to use directly to the electrolysis reactor Hoffman Voltameter. In these studies show the optimum production of 53.1 ml II testing.

IV. CONCLUSION

From the research that has been done on the implementation of photovoltaic systems and DC-DC converters for the production of hydrogen gas through electrolysis process was concluded as follows.

- The DC-DC converter in this study is designed to use the main components, namely IC 555 to drive a step-up transformer to produce greater output voltage and rectified using a diode bridge, then the converter output can be set using a potentiometer to be used as an input to electrolysis process. DC-DC converters are designed to work well after having tested with a power supply and an oscilloscope. Tests showed the increase in the input and output voltage value at the time of the source voltage gain of 86V 10V, 11V when the source voltage gain of 94,5V, when the source voltage of 12V increase 103,5V, when the source voltage 13V increase 112,7V, when the voltage source 14V gain of 121V and 15V when the source voltage gain of 130,3V.
- The amount of sunlight intensity and solar panel surface temperature measured in this study affect on the output of the solar panel and the production of hydrogen gas. In general, the average increase and the decrease is directly proportional, while in some time there is a change that is not directly proportional relationship between the intensity of sunlight and temperature, this is because the temperature on the surface of the solar panel and the measuring instrument is exposed to sunlight in a day had a transition time to the rise and decline, it is different from the light intensity value is rapidly changing.
- The test results directly from the solar panel to the electrolysis reactor in this study can be seen that the largest hydrogen production is 41.3 ml with light intensity of 30 140 lux, a temperature of 33.8 ° C, the voltage of 19.22 V and currents amounting to 86.8 mA. The formation of hydrogen gas using a DC-DC converter increases linearly with an output that can be set by the DC-DC converter designed. This is seen in testing using a battery with a converter output voltage variation that can be set. Of the four kinds of tests, the most optimum production occurs on the test using a system of solar panel design using DC-DC converters. In this research supports the optimum production of 53.1 ml.

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