STUDY OF PHOTOVOLTAIC SOLAR PANEL AND ITS PERFORMANCE

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Abstract— Renewable energy solution has achieved a great demand today to meet the energy crisis prevailing everywhere. Solar energy is rapidly gaining its popularity as an important source of this renewable energy. The photovoltaic (PV) technology is considered a way to generate electricity from sun. In order to obtain the maximum output from this PV cell can be kept orthogonal with the sun position. This paper proposes a model of Performance Study of Photovoltaic Solar Panel and Application to the sustainable way of lighting many villages in Bangladesh is expected to improve the general living standard of the communities. The proposed methodology has been tested for different parameters such as current-voltage (I-V), power-voltage (P-V), power-time (P-T) characteristics of the panel, effect of shadows on the panel and also comparison has been shown for two different position of panel to verify the output power improvement of the movable photovoltaic array compared to the fixed array. It has been realized that the performance of the panel, which studied was fairly good; even though the efficiency seems to be lower than the commercial solar panels. It has been speculated that if precaution can be taken to minimize the power losses due to various factors during the peak hour of sunlight, the performance of the locally studied panel would be better. Further work is going on to improve the performance of the cell. In this research, we have studied some techniques to utilize the full sunlight throughout a day and hence to obtain the maximum efficiency.

Index Terms— Solar Panel, Shadow Effect, Fixed Panel, Efficiency, Power Improvement, Adjusted Panel, Photovoltaic Cell.

1 INTRODUCTION

Energy is a prime requirement in our daily lives and it makes our everyday life so simple with the help of technological advanced machine. Energy is the ability to do work. It comes in different forms as heat (thermal), light (radiant), mechanical, electrical, chemical, and nuclear energy. All forms of energy are stored in different ways, in the energy sources that we use every day. These sources are divided into two groups, conventional and non- conventional sources [1].

Fossil fuels like coal, oil, petrol and natural gas are conventional sources of energy. These are limited, not environmentally sound and cannot last forever. By realizing this scientists are always looking for the new source of energy that will never run out and will be environmentally friendly. The reusable source of energy is termed as non-conventional source of energy which will never come to an end. It includes all renewable energy sources such as solar power, wind power, wave power, geothermal power and tidal power. The main source of these powers is 'Solar Energy' which is surplus and can be a best alternative of the conventional energy sources.

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As long as the ancient people used soled energy for heating home and setting fire to enemy ships but the various solar energy technologies are using today. At the very beginning of the solar technology, it is used for cooking food and distilling water to pumping water for irrigation. After the consecutive development of solar energy technology in 1954, Bell Telephone Laboratory discovered Photovoltaic (PV) cell more generally known as 'Solar Cell' is used to collect this solar energy from sunlight and store it in a suitable medium like battery or transfer it directly to power grid for electricity. Many developed countries around the world are already using this technology to generate electricity for their daily use.

Bangladesh, being a developing country is still going through electricity crisis. The electricity generated here is simply not enough to fulfill the daily need of the entire residence not to mention that many rural village areas are still deprived of electricity. In advanced countries 7.35 kW energy [2] per person is required to maintain standard of living and comfort. Energy consumption per capita over the world is 2.37 kW. However, in the developing countries it is 1.30kW per person but only 0.228 kW per person in Bangladesh [2]. This is to be mentioned here that one-third of the world population consumes about four fifths of the total world energy while a very meager share is left to the majority of the population living in developing or under developed countries. The world's energy consumption is rising drastically and changing the energy picture of the world. If the

current trend in technological progress and innovation continues, the demand for energy then will be five times greater than what it is now. In the developing countries like Bangladesh will generate strong demand of energy. To make up future energy demand our existence conventional sources will be run out within this century if we don't find alternatives. Besides this, to produce energy by the conventional sources is not environmentally sound due to the huge green house gas emission and therefore cause of global warning. However, scientists have been fully aware of this issue ever since the Rio Earth Summit in 1992 and the international community has committed itself to reducing the green house gases with the signature of Kyoto Protocol [3]. However, out of the alternate energy resources solar energy has emerged as one of the `most powerful, clean, safe and virtually inexhaustible sources of energy; world can depend on, in the year to come.

Once a system is developed which collect solar energy and converted into useful energy, the fuel is free. Since our country is exposed to the sun mostly throughout the year due to its geographical location lies between 20˚34′ and 26˚38′ North Latitude & 88˚01′ and 92˚41′ East Longitude, so a major portion of our country's electricity can be generated from solar energy. If one percent of the total land is used to harness solar energy for electricity then it can fulfill the present energy demand. Besides this, renewable energy can be particularly suitable for developing countries like Bangladesh because in rural and remote areas transmission and distribution of energy generated from conventional sources are difficult and expensive. Currently, the solar arrays that are being used for this purpose are all "fixed photovoltaic arrays" which provides moderate efficiency when the sun is directly facing the cells but the efficiency decreased as the sun moves/changes position throughout the whole day. Along with the advantages come disadvantages and the major disadvantage is the inefficiency of the solar cells. The efficiency of the system is very low, so the maximum potential of the system cannot be used. Recent work shows [4 -7] different types of methodology have been proposed so far to improve the efficiency of the solar panel.

In this paper an automatic movable solar array has been proposed. The proposed model will fixed and movable of the sun and thereby will improve the output power. Several experiments have been conducted to show the output power improvement of the movable array compared to the fixed array [8].

2 Experimental Section

In this study, the performance of the solar panel has been investigated. The value of the solar radiation has been collected at Nikketon Solar Project area under BRAC University (66, Mohakhali) in Dhaka. We have selected Dhaka region because we have done our research on the month of May which is longest month for the sun shine of the year over that region. We used different (50 watt and 3 watt) monocrystalline panels for our experiments. A load was connected (120 ohm resistor to our panel and a 12V-40AH battery with the panel) and readings of voltage and current were taken across the load for both the panel in the fixed position and moving position. The one and only intention of this research was to observe the improve efficiency of the solar photovoltaic cell applications. During the research we observed the characteristic curves of the solar panel for I-V, P-V and P-T. It is also observed the effect of shadow for different exposed on the panel and when the maximum electricity can be found from dawn to dusk in a day. Finally we collected data from the panel of fixed position and moveable position and drawn the characteristic curve for different values.

3 Results and Discussions

3.1 Current Voltage (I-V) Characteristic Curve

To investigate the current versus voltage (I-V) characteristic of our experimental panel the data was collected in a very basic manner and the corresponding I-V curve is displayed in figure-1. To collect the data values we changed the load across the terminals of the solar panel. By changing the load across the terminals the readings for current and voltage were taken for that specific load. Sets of voltage and current values are taken by gradually increasing the load.

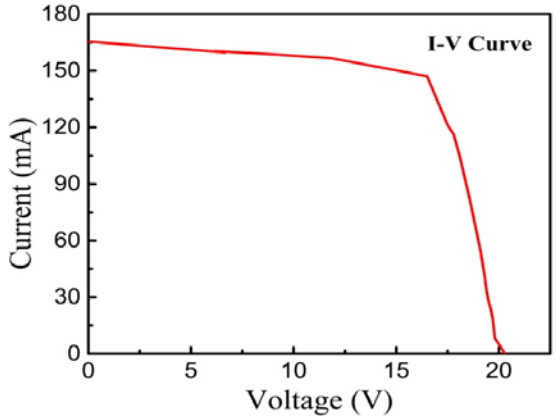

Fig. 1: Current Voltage (I-V) Characteristic Curve

From the curve it is observed that the maximum voltage is 20.3V, which is known as the open circuit voltage where the current in the circuit is zero. Also it is observed the short circuit current i. e. maximum current which is 166.5 mA. At short circuit current the voltage of the circuit is zero. However, the I-V characteristic which observed in our experiment is expected [9].

3.2 Power Voltage (P-V) Characteristic Curve

The power versus voltage curve is shown in figure -2. In this graph the maximum power is 2.43 watt and the corresponding voltage is 16.5 volt. Though we used a 3 watt panel but we expected the less output power because of the efficiency of the cells and the internal resistance of the panel, also for the wiring.

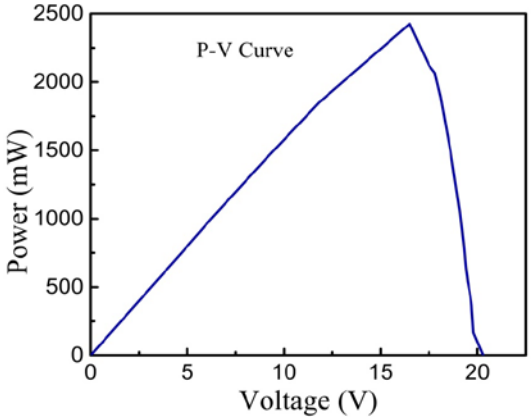

Fig. 2: Power Voltage (P-V) Characteristic Curve

For the panel we observed the variation of power with voltage and found that output power increase linearly with the increase of voltage till the power reaches its maximum value. The output power suddenly falls to zero after the maximum value which is also correlated with the open circuit voltage. To attain the maximum output power we used a load closer to 120 Ohm from the panel.

3.3 Characteristic of the Individual Cells of the Panel

To observe how each of the individual cells behaves to the sunlight and their impact on the open circuit voltage (Voc) and short circuit current (lsc) the experiment was carry out. Figure -3(a) shows the relation among the three parameters (no. of crystals exposed i.e. no. of modules, Voc and lsc).

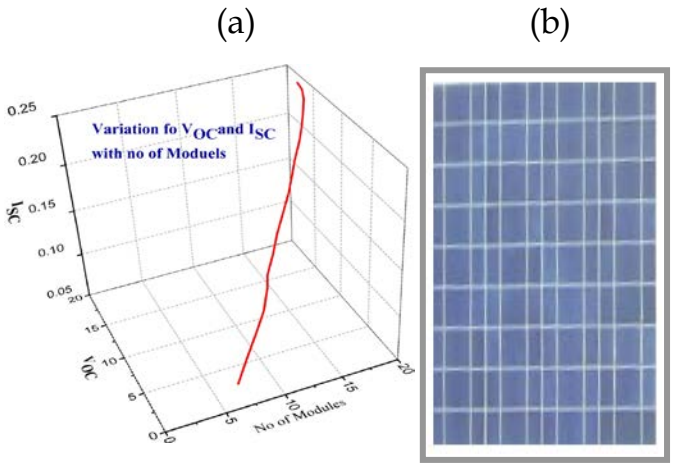

Fig. 3: (a) Variation of V_{OC} and I_{SC} with no of Modules; (b) Module of a 50 Watt panel

We have collected the values of V_{oc} and I_{sc} of a 36 cells poly-crystalline type solar panel. The results we have got and the three dimensional curve is quite logical that the three parameters are linearly co-related among each other. Since this is to an ideal case and there some internal loses, the curve is not perfectly linear but from what we got, we can conclude that a linear relationship exists between the three parameters.

3.4 Shadow Effect on Panel

To investigate the shadow effect we covered the whole panel with light impenetrable objects to cast shadows at different lengths from the panel and collected the data for Voc and Isc. After recorded the data values V_{oc} versus distance from the panel and Isc versus distance from the panel have been observed and shows in Figure-4.

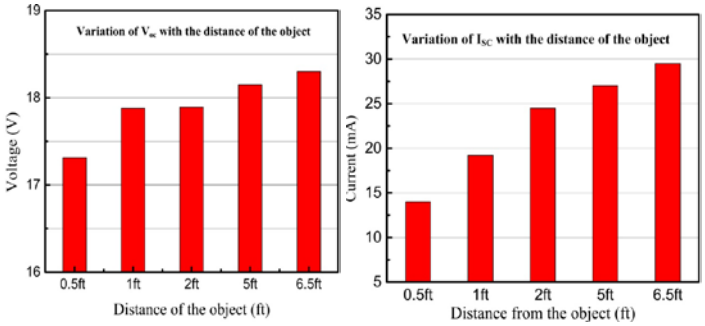

Figure-4: (a) Variation of open circuit voltage (Voc) with distance of the object and (b) Variation of short circuit current (Isc) with distance of the object.

In both the cases, we can observe that open circuit voltage and short circuit current increases as the object that is casting the shadow moves away from the panel. But, the notable change is in current. Current varies more with the shadow than the variation of voltage. Since current is the main parameter which determines the rate of charging a battery, so shadow causes a major chaw back in how quickly the panel can charge the load battery. The automatic solar tracking system [10-11] is inspired for the quickly charging and can easily overcome the shadow problem.

3.5 Output of fixed and adjusted solar Panel

In this research work we took the whole day readings of the voltage and current from a 50w panel to see how sun tracking mechanism can improve the efficiency. Data values are collected manually moving the panes to face the sun and also for fixed positions of the panel. Alongside, we have also tested our automatic solar tracking system to see how it behaves.

At the beginning to the day, we marked a spot which we considered to be the fixed position for the panels. For 50w panel a 12 volt battery connected to it. After every 30 minutes, we put the panel in the position and took the current and vol-

tage readings through and across the load respectively. Figure-5 shows the results of variation of current and voltage for the fixed and manually adjusted panel.

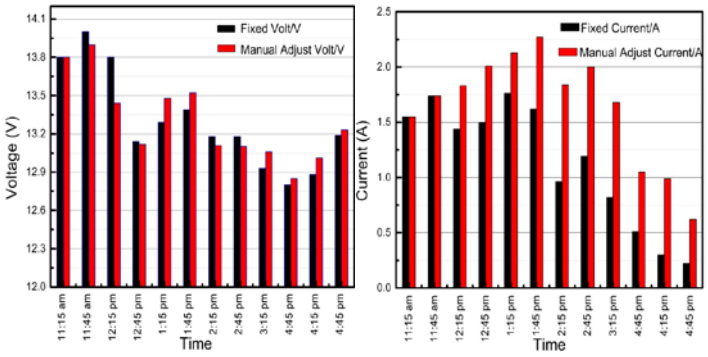

Figure-5: (a) Voltage vs. Time and (b) Current vs. Time for 50 watt Panel

To find out how much more power we can get by manually adjusting the panel data values were collected. From values we observed the power in manually adjusted panel is quit high [8] than that of fixed. Figure-6 represents the power for fixed and manually adjusted position. It is obderved the maximum power from 1.15 pm to 1.45 pm for both the positions.

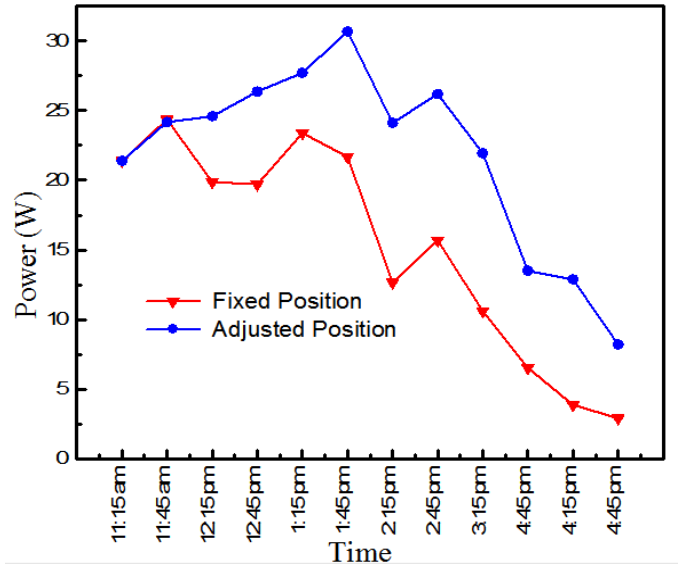

Figure-6: Power vs. Time curve for 50 watt Panel

The fixed solar panel as the base condition and used it to find how much more power we are getting by manual adjustment. The calculations are as follow:

We found out the power improvement for the 50 watt panel

- Total power of the fixed panel = 182.7 watt
- Total power of the manually adjusted panel = 259.78 watt

Power improvement by manually adjusting the panel: {(259.78 – 182.7)/ 182.7} × 100 = 42% (approx). It is observed that moveable solar panel works more efficiently than that of fixed solar panel. So from the experiment, we get the clear results to prove that the solar panel can improve the efficiency around 42% and more. Thus, it can be concluded that it is feasible and practical to make the solar panel moveable to make it more efficient.

4 Conclusion

To utilize solar photovoltaic system in a developing country like Bangladesh there are a enormous scope of development and implementation. Because of this marvelous form of harvesting energy, many houses in rural areas can now enjoy the blessing of electricity.

But solar energy utilization in rural area is not the answer to the question throw by solar energy. We have to harvest it efficiently and use it to our full benefit. In this study, it is effectively tried to propose the solar panel. Although this technology is nothing new to this world but it is something new for our country.

In this research, we have found increases energy by about 42% of the manually adjusted panel. With more works and better systems, we believe that this figure can raise more. And since the future, it is always wise to start early. Even 1% improvement in efficiency would save tons of fuels and ores in a year and that is not a small amount. Solar energy is unlimited, solar panels are easy to maintain and has a very long lifetime. All these favor the use of it in our country. We hope that there will be more research on this and our country will move forward to minimize the electricity crisis that if hitting us at the every moment.

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