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Effect of Dust on Output Power of Conventional Solar Panels in Bangladesh

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***Abstract*— There is a recent upsurge in the usage of renewable energy resources. Among renewable resources solar energy is the main contributor in the power generation in our country. Efficiency of existing solar panels is reduced due to many factors due to which the rated efficiency cannot be achieved. Dust on solar panel is one of the main factors that reduces it efficiency. Dust is barrier between sunlight and solar panel. In this paper we have discussed a method to improve the efficiency of a solar panel by removing the dust from its surface. It was found that efficiency of solar panel is improved by using dust cleaning method. The experiment was carried out using two solar panels having same rating. Dust from the surface of one panel was cleaned regularly and another one was kept as it is. The measured power was found to be higher at the panel that was cleaned regularly. Experimental data and results are discussed in details.**

Keywords*—— *Renewable energy, Solar panel, Power, Dust, Efficiency.

I. INTRODUCTION

Electricity generated from sunlight is called solar electricity and the process of Converting solar light into electricity is known as the photovoltaic process. The PV solar power represents one of the most promising renewable energy in the world. PV technology is well–proven for producing electricity [1-2].

In Bangladesh, so far only 43% of the total population has the access to electricity. However, with increasing demand for electricity, especially for industrial expansion, construction and domestic uses, the supply and power generation is facing tremendous pressure and load shedding has become a common occurrence in the urban areas, The PV generation shares 5% of total power generation in China, 12.1 % in Germany and 10% in India [3]. So, Bangladesh should also start using solar energy in the urban areas immediately to overcome the energy crisis. Solar PV systems have already made significant headway in Bangladesh like in other developing countries [4-8]. Recent pioneering attempts in this field have generated enthusiasm. In Bangladesh, solar home system (SHS) increase rapidly because of roughly 60% population of the country does not have access to grid electricity and are mostly dependent on biomass to meet their energy requirement. It is not effective for large power applications but effective for low power applications in home, shop and school etc.

PV system can be either grid connected or used in off-grid application in small power systems. In solar PV Process direct current (DC) electricity is produced. The output of Solar cell is proportional to the sunlight intensity. Output of PV is rated by manufacturers under Standard Test Condition (STC): temperature=25 ℃; solar irradiance (intensity) =1000 W/$m^2$and solar spectrum as filtered by passing through 1.5 thickness of atmosphere. These condition are easily recreated in a factory but the situation is different for outdoor. With the increasing use of PV system it is vital to know what effect active meteorological parameters such as dust, solar radiation, air humidity, wind speed, air temperature and PV panel surface temperature have on its efficiency.

In Bangladesh the sunlight falls directly in summer and transversely in winter [4-8]. For receiving maximum solar energy in Bangladesh solar panel was tilled 23.5° (sun's inclination angle with respect to ground surface in Bangladesh). Bangladesh on an average receive around 3.82-6.43 kwh/$m^2$of solar irradiation out of collectors' performance due to the pollution on a solar cells' surface. Past studies focused mainly on the thermal cells and the effects of dust accumulation on the mirror reflectance. Sand and soil are among the primary sources of natural degradation, among other airborne particulates, chemical weathering processes, as well as industrial carbon and other types of dirt [9]. It also restricts the sun light fall onto the solar panel.

One of the Contributing factors in the drop of efficiency of solar PV panels in Bangladesh as well as in other country is the accumulated dust on the panel [10-19]. The nature of the problem may vary by geographical locations. Moreover, from 5 to 15% reduction in peak power has been obtained by varies climatic conditions, especially accumulated dust. Also, a reduction by 2.78% per day of I_{sc} has been obtained [9]. On the other hand, V_{oc} has been decreased by 0.863% per day time. In a study by Shaharin et al. [10] regarding dust accumulation on a solar-village PV system near Riyadh indicated a 32% reduction in performance after eight months. Wakim [11] indicated a reduction in PV power by 17% due to sand accumulation on panels in Kuwait city after six days. Studies by Nahar and Gupta [12] and Saidur [13]show that performance may decrease by up to 20% every month by the accumulation of dust on unclean cell surfaces. Moreover, experiments conducted by Goossens and Van Kerschaever [14] indicate that high wind speeds promote dust accumulation on surfaces. No studies yet have been conducted to correlate the quantity of dust deposition and resultant drops in PV performance. Tropical regions such as the Indian subcontinent, the Middle-East, Saharan Africa and the south-western United

States are particularly vulnerable to the accumulation of dust on existing

PV installations. Mani and Pillai [15-16] report that dustrelated degradation in PV performance is worse in tropical regions where arrays are installed with lower tilt angles. The settlement of dust and sand on cell surfaces may be uniform or non-uniform depending on the size of the PV arrays and the terrain of the location [17-19]. Furthermore, the study also indicated that the influence of dust on PV performance would be higher in spring and summer than in autumn and winter [17-19]. Though there are some works on how to increase the efficiency by addressing different factors but there are relatively less works to see the effect of accumulated dust on solar panel. Especially, no significant works have been observed to increase the efficiency of solar panel in Bangladesh context despite the fact that Bangladesh is a summer dominant country where dust on solar panel is a crude reality. Most of the studies surveyed covered electrical performance aspects and parameters, represented in measuring several parameters of dusty/polluted PV modules in comparison to clean PV modules, such as the short circuit current, the maximum current, the open circuit voltage, the maximum voltage, the output power, the energy output, and the other weather parameters. Only a few studies were found regarding this aspect, where the optical transmittance of dusty/polluted PV panels were measured and presented according to the dust density on their surfaces. Moreover, some of these studies demonstrated the transmittance results in correlation to other parameters, such as different tilt angles of PV modules, the number of days of exposure of PV panels to the outdoor dust/polluted environment, analysis tools were rarely utilized, owing to the sun-earth geometry and the location of Dhaka, Bangladesh.

As solar panel efficiency is not very high so, we need to retain its maximum efficiency. In this paper, the influence of dirt accumulation on the efficiency of solar PV panels is assessed experimentally by using natural dust.

II. METHOD AND RESULTS

To study the effect of dust on solar panel efficiency, two solar panels were placed in open place during the month of September, 2018 at same position in a dusty area.The electrical specifications of the panel are as follows:

At STC (1000W/m2, AM 1.5 spectrums cell temperature 25 ℃) nominal values:

Voltage (V_{mp}) : 17.3V

Current (I_{mp}) : 0.58A

Open Circuit Voltage (V_{oc}) : 21.6V

Short Circuit Current (I_{sc}) : 0.628A

Maximum Output Power : 10 W

Fig 1: Two solar panels placed at open place exposed to sunlight, one is cleaned regularly (left one) and another one was kept without cleaning.

Module dimension : 300 mm × 25mm

The height of each panel from the land surface was 5 feet. Both of the solar panels were kept inclined at an angle of 23.50^0 with the horizontal. The length of the panel was aligned along the north south direction.Tests were started with two clean solar PV panels in order to record and measure the effects of dust on the performance of the PV panels. Experiments were performed by applying natural dusts on the solar PV panel.

Figure 1 shows the solar panels (rated10W) used in our experiment.The solar panel module we used was made of silicon mono-crystal cells. The system was installed and kept at the outdoor environment for three weeks or accumulation of dust on the solar panel. The radiation energy was delivered by the sun. For the measurements of voltage and current, Lutron DM-9080 Digital multimeter was used. Natural dust was used to see the effect of dust accumulation. Value of current and voltage were measured from 8am to 4 pm with 30 minute interval.

TABLE I:DAY OBSERVATION DUE TO DUST.

Measurement Time	With dust(watt)	Without dust(watt)
8.30AM	3.15	4.6
9.00AM	3.72	5.4
9.30AM	5.54	7.8
10.00AM	6.14	8.49
10.30AM	7.37	9.88
11.00AM	7.68	9.98
11.30AM	7.61	10.12
12.00PM	7.29	10.03
1.00PM	8.06	10.47
1.30PM	8.25	10.72
2.00PM	7.41	8.77
2.30PM	4.15	6.63
3.00PM	3.74	5.95
3.30PM	2.77	5.7
4.00PM	2.7	5.1

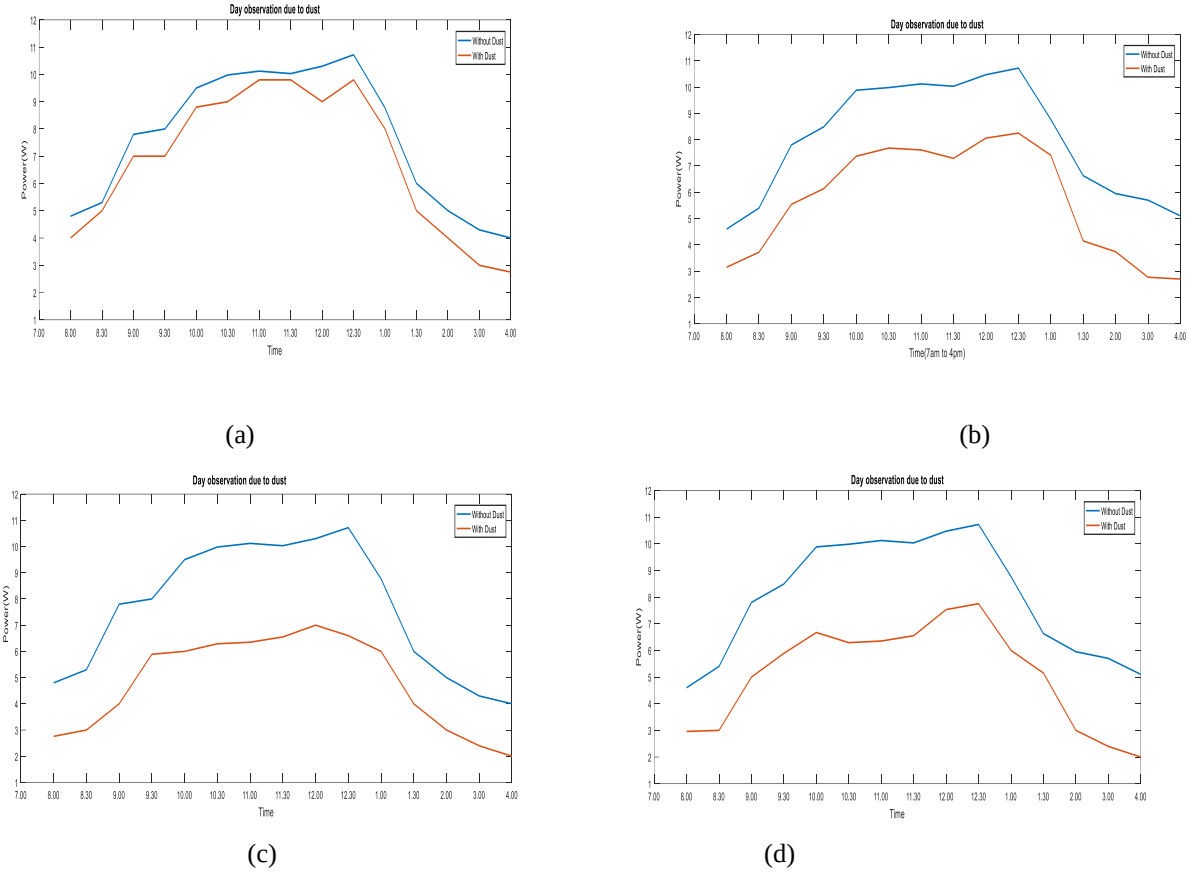

Fig 2: Periodically measured output power vs time for two solar panels, one without dust (blue) and another with dust (red), (a) after 5 days (b) after 1 week (c) after two weeks and (d) after three weeks.

For measuring current, we used 5v DC Fan as a load. As the rated voltage and current of two panels were same so, initially the output from both the panel were same. Then, after five days we cleaned one solar panel by cloth and another panel was lfeft as it was. From now on we will refer these two panelsas panel-1 (without dust panel)and panel-2 (dusty panel). We measured the voltage and current periodically on both panels. Power was calculated from these data. We maintained this process for three weeks and collected data regularly. Measured data are shown in Table I.

TABLE II: POWER LOSS DUE TO DUST

Day	V_1(V)	I_1(A)	P_1(W)	V_2(V)	I_2(A)	P_2(W)	P_1-P_2 (W)
Day-1	20.4	0.61	12.44	20.4	0.61	12.44	0
Day-2	20.4	0.58	11.83	19.5	0.55	10.72	1.105
Day-3	20.3	0.58	11.77	19.5	0.5	9.75	2.02
Day-4	20.4	0.6	12.24	19.3	0.46	8.878	3.362
Day-5	20.1	0.59	12.21	19.1	0.38	7.25	4.952

From Table I, it can be easily said that the power of clean panel (panel-1) is greater than the power of dusty panel (panel-2). When the sun intensity is low(8 am to 9 am), the percentage difference of power between panel-1 and panel-2 was quite high(around 35%). During midday this difference is around 20%. As the panel-2 is barred from sunlight due to dust so, it is expected that at low sunlight, effect of dust on output power of panel-2 would be severe. During midday, received sunlight by dusty panel increases compared to morning and hence output power difference with panel-1 reduces. But, still the difference in power is around 20% even on midday which is quite high. Thus, dust decreases the efficiency of the panel and reduces its output power significantly.

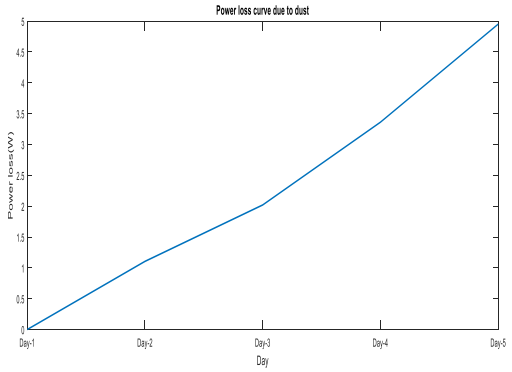

Fig.3: Graph of Power loss vs day for panels without dust and with dust.

Fig-2 shows the gradual decrease of the power,as represented in Table II, of dusty panel in compared to panel-1 which was cleaned regularly. Fig-2 (a) to (d) shows the

recorded power in different sections of three weeks. It can be observed from Fig-2 that efficiency of panel-2 is decreasing gradually, increasing the gap between two curves in consecutive weeks.

Fig-3 shows this power loss directly with respect to number of days of experiment. Again it can be clearly observed that the loss increases continuously and consistently in a linear way with the increase of number of days. If this situation is allowed to continue then at one point no power can be achieved from the dusty panel.

III. CONCLUSION

Natural dust is one of the causes to reduce the output of the solar panel.Efficiency of existing solar panels are reduced due to these factors due to which the rated efficiency cannot be achieved. Dust on solar panel is one of the main factors that reduces it efficiency. Dust is barrier between sunlight and solar panel. This work discussed a method to improve the efficiency of a solar panel by removing the dust from its surface. It was found that efficiency of solar panel is improved by using dust cleaning method. The experiment was carried out using two solar panels having same rating. Dust from the surface of one panel was cleaned regularly and another one was kept as it is. The measured power was found to be higher at the panel that was cleaned regularly. Experimental data and results are discussed in details. It has been observed that output of the dusty solar panel reduces by around 35% during morning and around 20% during midday in compared to panel which was cleaned regularly to keep it dust free. This observation is significant as it shows the degree of reduction in efficiency of a solar panel due to dust accumulation and therefore highlights the importance of keeping it dust free by using any suitable mechanism. Simplest way is to wipe it manually at least once in a month, if not regularly or weekly. However, this may not be possible if the solar power plant is large containing too many solar panels. In such case, a wiper can be set on the solar panel which can be driven automatically either any elecro-mechanical procedure. Alternatively, water can be flown from a water tank by single or multiple pipes that has opening above the solar panels.In this way, beside cleaning, temperature of the panel will be also reduced that will further increase the efficiency of the solar panel as efficiency decreases when the solar panel is heated by sun. Whatever the mechanism is, dust must be removed from the surface of solar PV panel in order to ensure highest performance, given the fact that it is still a costly form of energy source.

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