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Investigations of Parameters of Silicon Solar Array with Different Size

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ABSTRACT

Sun light replenishes the earth with energetic radiation, which sustains the life on earth and It also considered as a primary source of energy. The solar energy is converted to electricity using the solar cells so the effect of solar radiation on the performance of the solar cell is an important factor. In this paper, we have compared various parameters of solar cell like open circuit voltage, short circuit current, maximum output power and efficiency by changing the area of solar array from 270cm^2 to 299.52cm^2 for the location of Latitude: 23°49' 47.5'' N, Longitude: 73°0' 10.8''E.

Key words: Polycrystalline silicon solar cells, Area of Silicon Solar Cell, Solar Irradiance, Efficiency

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INTRODUCTION

The huge amount of energy is obtained from the non – renewable energy sources like fossil fuel these sources are converted in an electricity and heat. The global Warming occurred because mutilation of the atmosphere. These sources are limited [1]. Solar energy is the best alternative of use of non – renewable energy sources which provides clean and unlimited pollution free energy. Sun light is converted to electrical energy using solar module which is congregations of solar cells. Silicon solar module is quite much prevalent solar module and occupying approximate 90% of the solar market and widely used solar module [2]. The spectral distribution of solar irradiance and temperature are the very crucial parameters which explain the operating condition of solar module. The performance of solar module is considered under standard conditions (SRC illuminations: 1000 W/m^2, temperature = 25°C, AM1.5 reference spectrum) and that condition never occurs at the real insolation place so that the performance of the solar module will change [3]. Only few amount of incident solar radiation is converted into electricity by the solar module and the rest of the illuminated energy are absorbed by the material and converted into the heat, which results increase in the temperature of the solar array eventually efficiency reduces with respect to the increment in temperature of the PV module [4].

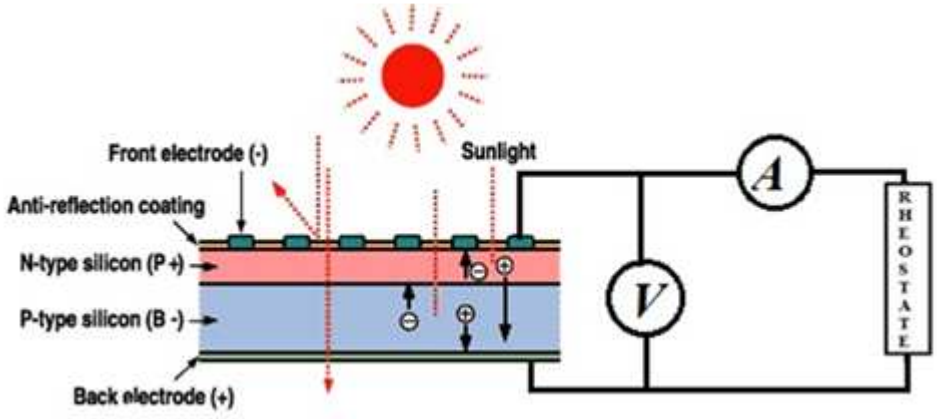

Fig. 1 Solar PV Array diagram for I – V Characteristics

EXPERIMENTAL WORK

By illuminating the solar array with the sun light, the open circuit voltage is measured across the voltmeter which is connected parallel to the solar array and short circuit current is measured by the ammeter which is connected in series to solar array and the rheostat. By changing the value of resistance through the rheostat, the current - voltage characteristics of the solar array is measured. The area of the solar array (270 cm^2 to 299.52cm^2) has been changed for the whole day illumination measurement. The different parameters of the solar array are discussed here with appropriate equations.

Efficiency

The efficiency of the solar cell is defined as the ratio of maximum output power to illuminated radiation and area of solar array.

$$\eta = \frac{P_m}{P_{in} \times A} \tag{1}$$

The relation between the temperature of the solar array and open circuit voltage is also expressed as

$$V_{oc} = \frac{kT}{q} ln\left(\frac{I_L}{I_0} + 1\right) \approx \frac{kT}{q} ln\left(\frac{I_L}{I_0}\right) \tag{2}$$

Differentiating Eq. (2) by T. We will get the rate of change of V_{oc} as a function of temperature.

$$\frac{d(V_{oc})}{dT} = \frac{1}{T}(V_{oc} - \frac{E_g}{q}) \tag{3}$$

Since Eg/q term will always be higher than the open circuit voltage (V_{oc}) term in Eq. (3). The change in V_{oc} is obtained because of the increase in temperature will always be negative, i.e. the V_{oc} decreases as the temperature of the cell increases.

Using the above approximation, the equation for the cell efficiency can be written as:

$$\eta = \frac{I_{sc}V_{oc}FF}{P_{in}} = \frac{nI_L\frac{kT}{q}ln\left(\frac{I_L}{I_0}\right)FF}{P_{in}} \tag{4}$$

Where, P_{in} is the intensity of solar radiation.

From Eq. (3), The radiation intensity (P_{in}) decreases, the open circuit voltage (V_{oc}) decreases with the decrease in light generated current (I_L) (decrease in I_L is related to decrease in Solar radiation intensity (P_{in})), both of which cancelled out so efficiency will decrease with the decrement in solar radiation intensity (P_{in}), whereas efficiency increases if the radiation intensity (P_{in}) is decreased [5-7].

Table -1 Observation Table

Date : 01 NOV 2013		Area of Array : 270 cm^2				Area of Array : 299.52 cm^2			
Time (O'Clock)	**P_{in} (mW/cm^2)**	**V_{oc} (Volt)**	**I_{sc} (mAmp)**	**P_{max} (mWatt)**	**n (%)**	**V_{oc} (Volt)**	**I_{sc} (mAmp)**	**P_{max} (mWatt)**	**n (%)**
8:00	49	10.24	195.00	1427.50	10.79	10.75	270.00	2112.00	14.39
9:00	84	10.08	345.00	2301.75	10.15	10.30	502.00	3540.50	14.07
10:00	100	9.79	410.00	2495.01	9.24	10.20	500.00	3454.00	11.53
11:00	102	9.55	440.00	2518.50	9.14	10.00	520.00	3432.00	11.23
12:00	106	9.40	460.00	2555.00	8.93	9.92	550.00	3443.50	10.85
13:00	105	9.48	450.00	2548.80	8.99	10.08	540.00	3700.00	11.76
14:00	97	9.90	400.00	2541.00	9.70	10.20	480.00	3440.00	11.84
15:00	88	10.00	365.00	2402.50	10.11	10.32	430.00	3150.00	11.95
16:00	54	10.22	215.00	1517.00	10.40	10.40	310.00	2290.60	14.16
17:00	42	10.30	168.40	1242.77	10.96	10.71	260.00	1989.50	15.81

Date : 02 NOV 2013		Area of Array : 270 cm^2				Area of Array : 299.52 cm^2			
Time (O'Clock)	**P_{in} (mW/cm^2)**	**V_{oc} (Volt)**	**I_{sc} (mAmp)**	**P_{max} (mWatt)**	**n (%)**	**V_{oc} (Volt)**	**I_{sc} (mAmp)**	**P_{max} (mWatt)**	**n (%)**
8:00	47	10.38	219.00	1550.00	12.21	10.70	280.00	2021.00	14.36
9:00	80	10.25	325.00	2068.80	9.58	10.60	430.00	3048.80	12.72
10:00	102	10.18	405.00	2511.60	9.12	10.45	520.00	3628.80	11.88
11:00	103	10.12	415.00	2523.20	9.07	10.35	550.00	3723.00	11.73
12:00	111	9.65	470.00	2555.00	8.53	10.28	550.00	3640.00	10.95
13:00	106	9.85	430.00	2523.40	8.82	10.32	520.00	3504.00	11.25
14:00	104	10.00	417.00	2533.30	9.02	10.40	540.00	3712.50	12.03
15:00	82	10.21	334.00	2309.50	10.43	10.55	450.00	3178.50	12.94
16:00	72	10.32	315.00	2257.60	11.61	10.62	410.00	2923.20	13.56
17:00	32	10.40	144.00	1079.50	12.49	10.68	208.00	1500.02	15.65

Date : 03 NOV 2013		Area of Array : 270 cm^2				Area of Array : 299.52 cm^2			
Time (O'Clock)	**P_{in} (mW/cm^2)**	**V_{oc} (Volt)**	**I_{sc} (mAmp)**	**P_{max} (mWatt)**	**n (%)**	**V_{oc} (Volt)**	**I_{sc} (mAmp)**	**P_{max} (mWatt)**	**n (%)**
8:00	39	10.26	162.00	1135.68	10.79	10.78	240.00	1786.00	15.29
9:00	73	10.12	305.00	2011.10	10.20	10.65	410.00	2940.00	13.45
10:00	90	9.92	370.00	2240.00	9.22	10.52	460.00	3218.50	11.94
11:00	98	9.75	420.00	2310.00	8.73	10.48	490.00	3388.00	11.54
12:00	103	9.55	454.00	2379.15	8.56	9.95	540.00	3532.50	11.45
13:00	97	9.78	418.00	2329.80	8.90	10.46	480.00	3344.00	11.51
14:00	94	9.86	405.00	2296.80	9.05	10.52	460.00	3268.00	11.61
15:00	88	10.05	375.00	2271.50	9.56	10.60	430.00	3116.00	11.82
16:00	59	10.23	245.00	1694.00	10.63	10.65	340.00	2492.00	14.10
17:00	21	10.30	86.10	621.85	10.97	10.85	143.00	1071.56	17.04

Date : 04 NOV 2013		Area of Array : 270 cm^2				Area of Array : 299.52 cm^2			
Time (O'Clock)	**P_{in} (mW/cm^2)**	**V_{oc} (Volt)**	**I_{sc} (mAmp)**	**P_{max} (mWatt)**	**n (%)**	**V_{oc} (Volt)**	**I_{sc} (mAmp)**	**P_{max} (mWatt)**	**n (%)**
8:00	42	10.30	160.00	1197.00	10.56	10.70	260.00	1795.50	14.27
9:00	68	10.08	300.00	1874.40	10.21	10.65	400.00	2726.40	13.39
10:00	88	9.98	378.10	2276.10	9.58	10.30	478.00	3086.10	11.71
11:00	100	9.88	435.00	2356.00	8.73	10.08	535.00	3116.00	10.40
12:00	105	9.60	460.00	2431.80	8.58	9.85	560.00	3203.80	10.19
13:00	99	9.82	422.00	2380.00	8.90	10.20	522.00	3080.00	10.39
14:00	96	9.90	405.00	2247.50	8.67	10.40	505.00	3034.00	10.55
15:00	90	10.10	380.00	2241.45	9.22	10.52	480.00	3085.05	11.44
16:00	62	10.30	250.00	1736.35	10.37	10.68	350.00	2583.35	13.91
17:00	25	10.35	90.00	728.46	10.79	10.72	145.00	1125.00	15.02

Date : 05 NOV 2013		Area of Array : 270 cm^2				Area of Array : 299.52 cm^2			
Time (O'Clock)	**P_{in} (mW/cm^2)**	**V_{oc} (Volt)**	**I_{sc} (mAmp)**	**P_{max} (mWatt)**	**n (%)**	**V_{oc} (Volt)**	**I_{sc} (mAmp)**	**P_{max} (mWatt)**	**n (%)**
8:00	39	10.20	179.00	1345.41	12.78	10.55	232.00	1792.00	15.34
9:00	74	10.09	289.00	2073.90	10.38	10.51	400.00	3060.00	13.81
10:00	96	9.72	430.00	2574.00	9.93	10.45	470.00	3388.00	11.78
11:00	100	9.64	455.00	2606.10	9.65	10.21	500.00	3439.30	11.48
12:00	104	9.44	470.00	2634.05	9.38	10.18	520.00	3379.30	10.85
13:00	103	9.50	465.00	2623.50	9.43	10.20	540.00	3528.00	11.44
14:00	99	9.68	450.00	2592.50	9.70	10.33	510.00	3633.10	12.25
15:00	88	9.95	375.00	2433.50	10.24	10.40	450.00	3306.00	12.54
16:00	72	10.12	285.00	2075.00	10.67	10.48	387.00	2926.80	13.57
17:00	39	10.18	180.00	1328.25	12.61	10.62	220.00	1710.00	14.64

Date : 06 NOV 2013		Area of Array : 270 cm^2				Area of Array : 299.52 cm^2			
Time (O'Clock)	**P_{in} (mW/cm^2)**	**V_{oc} (Volt)**	**I_{sc} (mAmp)**	**P_{max} (mWatt)**	**n (%)**	**V_{oc} (Volt)**	**I_{sc} (mAmp)**	**P_{max} (mWatt)**	**n (%)**
8:00	36	10.27	135.00	988.00	10.16	10.66	205.00	1592.80	14.77
9:00	63	10.05	245.00	1670.00	9.82	10.52	355.00	2640.00	13.99
10:00	79	9.85	315.00	2035.50	9.54	10.46	430.00	3126.50	13.21
11:00	86	9.66	345.00	2124.00	9.15	10.39	435.00	2880.00	11.18
12:00	98	9.40	410.00	2325.00	8.79	10.28	500.00	3168.00	10.79
13:00	94	9.50	385.00	2240.00	8.83	10.32	490.00	3192.00	11.34
14:00	87	9.61	350.00	2131.50	9.07	10.39	485.00	3307.50	12.69
15:00	83	9.70	335.00	2093.50	9.34	10.42	477.00	3406.50	13.70
16:00	58	10.10	228.00	1572.55	10.04	10.55	330.00	2442.80	14.06
17:00	33	10.30	123.50	918.00	10.30	10.62	185.00	1420.55	14.37

Date : 07 NOV 2013		Area of Array : 270 cm^2				Area of Array : 299.52 cm^2			
Time (O'Clock)	**P_{in} (mW/cm^2)**	**V_{oc} (Volt)**	**I_{sc} (mAmp)**	**P_{max} (mWatt)**	**n (%)**	**V_{oc} (Volt)**	**I_{sc} (mAmp)**	**P_{max} (mWatt)**	**n (%)**
8:00	38	10.35	140.00	1123.20	10.95	10.52	207.00	1591.00	13.98
9:00	70	10.10	255.00	1918.20	10.15	10.41	370.00	2753.10	13.13
10:00	82	9.90	325.00	2283.30	10.31	10.34	442.00	3118.50	12.70
11:00	90	9.75	350.00	2377.96	9.79	10.19	460.00	3120.00	11.57
12:00	100	9.50	421.00	2481.60	9.19	10.02	495.00	3165.92	10.57
13:00	98	9.65	398.00	2444.00	9.24	10.22	465.00	3159.00	10.76
14:00	90	9.70	359.00	2288.00	9.42	10.36	446.00	3151.50	11.69
15:00	88	9.75	343.00	2265.00	9.53	10.44	430.00	3150.00	11.95
16:00	62	10.20	220.00	1676.90	10.02	10.51	340.00	2577.25	13.88
17:00	39	10.50	128.00	1075.00	10.21	10.59	220.00	1720.00	14.72

Date : 08 NOV 2013		Area of Array : 270 cm^2				Area of Array : 299.52 cm^2			
Time (O'Clock)	**P_{in} (mW/cm^2)**	**V_{oc} (Volt)**	**I_{sc} (mAmp)**	**P_{max} (mWatt)**	**n (%)**	**V_{oc} (Volt)**	**I_{sc} (mAmp)**	**P_{max} (mWatt)**	**n (%)**
8:00	37	10.45	130.00	1058.40	10.59	10.55	210.00	1595.80	14.40
9:00	76	10.08	305.00	2001.00	9.75	10.41	425.00	3112.20	13.67
10:00	93	9.75	375.00	2280.00	9.08	10.29	478.00	3363.00	12.07
11:00	97	9.71	395.00	2376.00	9.07	10.11	501.00	3432.00	11.81
12:00	109	9.40	450.00	2480.00	8.43	10.02	600.00	3535.00	10.83
13:00	105	9.50	440.00	2415.00	8.52	10.21	540.00	3475.00	11.05
14:00	80	9.98	315.00	2028.00	9.39	10.33	451.00	3048.80	12.72
15:00	76	10.05	306.00	2009.12	9.79	10.43	448.00	3112.20	13.67
16:00	56	10.15	220.00	1522.50	10.07	10.47	345.00	2424.40	14.45
17:00	41	10.30	153.00	1155.00	10.43	10.52	245.00	1830.65	14.91

Date : 09 NOV 2013		Area of Array : 270 cm^2				Area of Array : 299.52 cm^2			
Time (O'Clock)	**P_{in} (mW/cm^2)**	**V_{oc} (Volt)**	**I_{sc} (mAmp)**	**P_{max} (mWatt)**	**n (%)**	**V_{oc} (Volt)**	**I_{sc} (mAmp)**	**P_{max} (mWatt)**	**n (%)**
8:00	26	10.30	100.60	769.25	10.96	10.42	164.10	1238.73	15.91
9:00	55	10.10	210.00	1494.00	10.06	10.30	341.00	2470.40	15.00
10:00	79	9.85	306.00	1955.00	9.17	10.26	437.00	3126.50	13.21
11:00	90	9.50	370.00	2100.00	8.64	10.21	475.00	3349.70	12.43
12:00	95	9.35	390.00	2131.25	8.31	10.02	500.00	3185.00	11.19
13:00	92	9.45	377.00	2088.45	8.41	10.17	520.00	3520.00	12.77
14:00	75	9.92	288.00	1880.00	9.28	10.20	450.00	3075.00	13.69
15:00	67	10.03	258.00	1782.50	9.85	10.31	430.00	2983.00	14.86
16:00	45	10.15	176.00	1299.60	10.70	10.39	275.00	2009.00	14.91
17:00	26	10.25	104.50	805.10	11.47	10.45	168.00	1253.73	16.10

Date : 10 NOV 2013		Area of Array : 270 cm^2				Area of Array : 299.52 cm^2			
Time (O'Clock)	**P_{in} (mW/cm^2)**	**V_{oc} (Volt)**	**I_{sc} (mAmp)**	**P_{max} (mWatt)**	**n (%)**	**V_{oc} (Volt)**	**I_{sc} (mAmp)**	**P_{max} (mWatt)**	**n (%)**
8:00	37	10.35	159.00	1267.50	12.69	10.45	235.00	1749.00	15.78
9:00	73	10.00	260.00	1944.00	9.86	10.39	418.00	2975.00	13.61
10:00	101	9.92	380.00	2589.65	9.50	10.22	580.00	3927.00	12.98
11:00	113	9.10	440.00	2738.80	8.98	10.10	620.00	4070.00	12.03
12:00	116	9.08	460.00	2790.00	8.91	10.02	630.00	3886.00	11.18
13:00	114	9.10	455.00	2782.08	9.04	10.15	625.00	4372.50	12.81
14:00	113	9.30	440.00	2772.20	9.09	10.26	622.00	4455.00	13.16
15:00	102	9.85	370.00	2584.00	9.38	10.31	570.00	4165.00	13.63
16:00	83	10.03	290.00	2146.50	9.58	10.37	480.00	3555.00	14.30
17:00	39	10.19	179.00	1361.70	12.93	10.45	240.00	1827.00	15.64

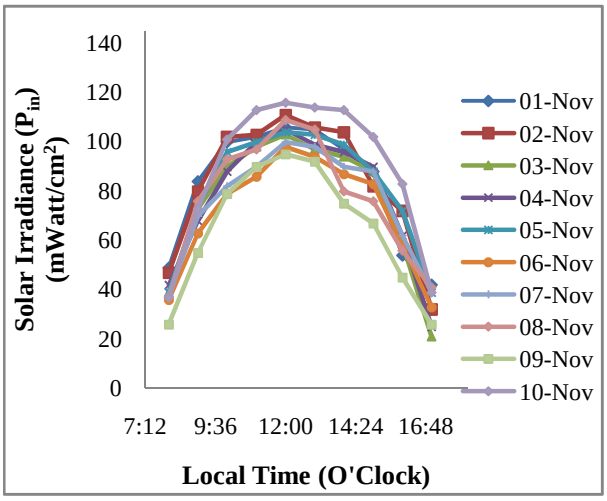

Fig. 2 Solar Irradiance vs Local Time

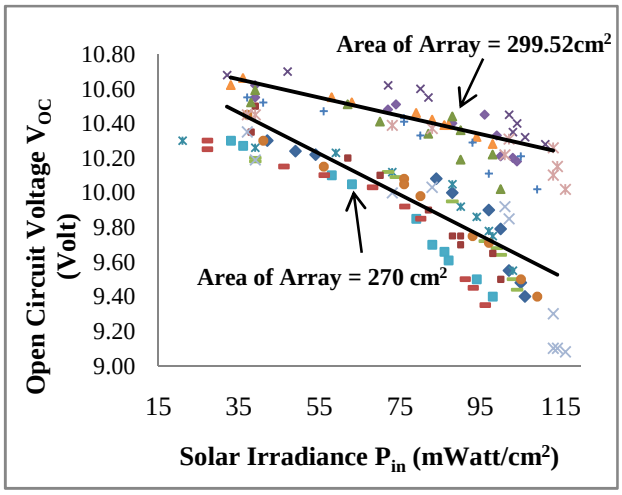

Fig. 3 Open Circuit Voltage vs Solar Irradiance

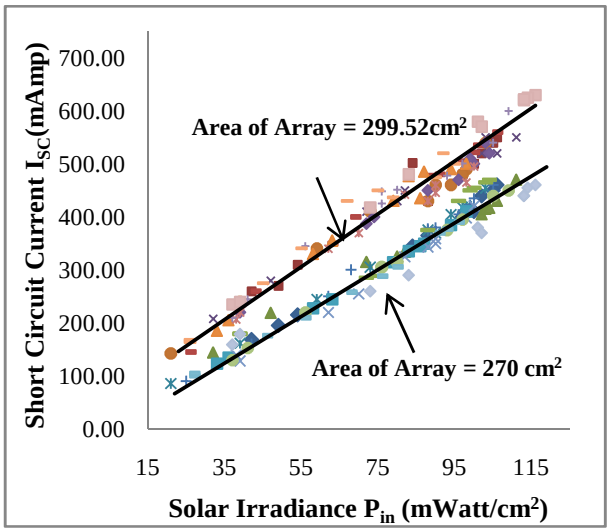

Fig. 4 Short Circuit Current vs Solar Irradiance

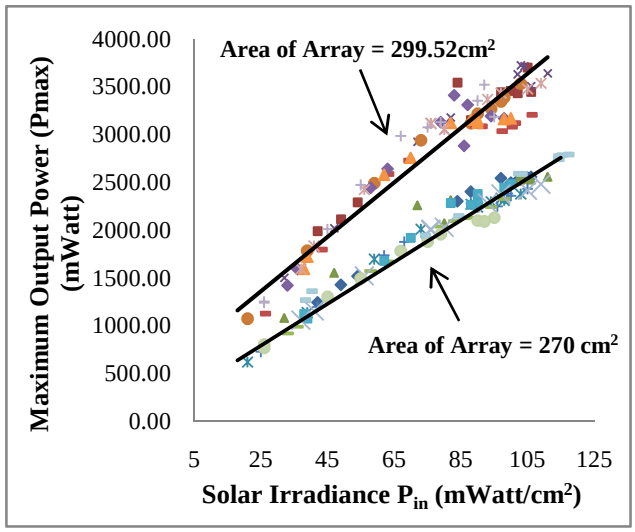

Fig. 5 Maximum Output Power vs Solar Irradiance

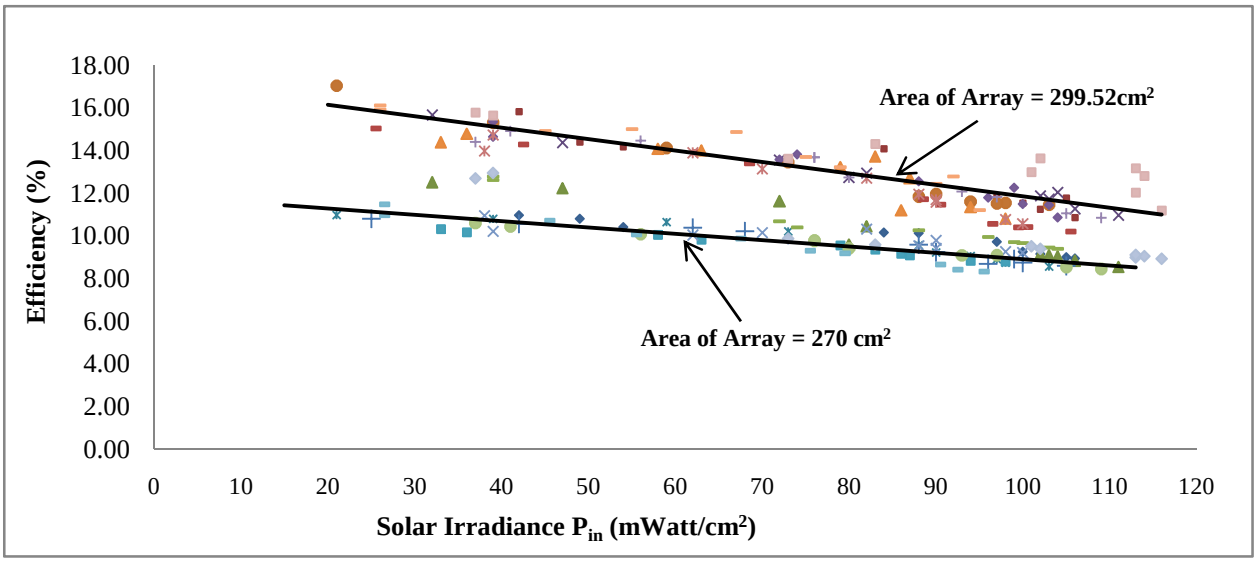

Fig. 6 Efficiency vs Solar Irradiance

RESULTS AND DISCUSSION

After the number of experiments we observed that the open circuit voltage (V_{oc}), short circuit current(I_{sc}), maximum power output(P_{max}) and efficiency(η) of polycrystalline silicon solar cells array increase by enhancing the area of the polycrystalline silicon solar array from 270cm^2 to 299.52 cm^2 for 1st November to 10th November for the Latitude: 23°49' 47.5" N, Longitude: 73°0' 10.8"E. Figure – 2 states the relation between solar irradiance and local time which indicates that from morning to noon time the solar irradiance increases after that from noon to evening it decreases. Figure – 3 explains the open circuit voltage (V_{oc}) decreases with increment in solar irradiance according to equation – 3 (V_{oc} also depends on the temperature of the solar array. It decreases as the temperature of the array increase). We can observe drastic change in the open circuit voltage after enhancing the area of the solar panel that is due to large area can capture more solar light and that generate more hole and electrons results in more open circuit voltage across solar array. Figure – 4 indicates short circuit current increases with increment in solar irradiance and we can also observe here drastic enhancement in short circuit current by enhancing the area of the array. Figure – 5 shows maximum power output across solar PV array increases as increment in solar irradiance and dramatic enhancement in maximum power is observed by changing the area of the array. Figure – 6 explains the relation between solar panel efficiency and incident solar irradiance that indicates the efficiency decreases with solar irradiance according to equation – (3) but sudden enhancement in efficiency is observed by enhancing the area of solar PV array that is due to increment in the open circuit voltage according to equation – (3).

CONCLUSION

In this paper we have concentrated on variation of various parameters of solar cell with respect to the variation of solar irradiance and the solar cell array area in real sense application. We have compared the Open Circuit Voltage, Short Circuit Current, Maximum Power Output and Efficiency of solar array with different size (270cm^2 and 299.52 cm^2). It is confirmed that the open circuit voltage decreases with solar irradiance but when increased the area of solar array from 270cm^2 to 299.52 cm^2 for same solar irradiance data we got enhancement in open circuit voltage. The short circuit current and maximum output power increase with solar irradiance and drastic increment is observed in short circuit current and maximum output power by enlarging the solar array area from 270cm^2 to 299.52 cm^2. The solar cell efficiency decreases with solar irradiance but prompt increment in efficiency is observed for same solar irradiance data with different size (in the sense of area from 270cm^2 to 299.52 cm^2) of the solar array.

REFERENCES

[1] Davud Mostafa Tobnaghi, Rahim Modatov and Daryush Naderi, The Effect of Temperature on Electrical Parameters of Solar Cell, *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering*, **2013**, 2 (12), 6404 – 6407.
[2] A El-Shaer, TDY Tadros and MA Khalifa, Effect of Light Intensity and Temperature on Crystalline Silicon Solar Modules Parameters, *International Journal of Emerging Technology and Advance Advanced Engineering*, **2014**, 4(8), 311 - 318.
[3] Qusay Assim Hanna Al-Nazer, Noorah Mohammed Ahmed Al-barghoothi and Noor Ahmed Salman Al-Ali, The Effect of Temperature variations on Solar Cell Efficiency, *International Journal of Engineering, Business and Enterprise Applications*, **2013**, 4(2), 108 – 112.
[4] Swapnil Dubey, Jatin Narotam Sarvaiya and Bharath Seshadri, Temperature Dependant Photovoltaics (PV) Efficiency and its Effect on PV Production in the world, *PV Asia Pacific Conference* **2012**, *Energy Procedia*, **2013**, 33, 311 – 321.
[5] Chetan Singh Solanki, *Solar Photovoltaics, Fundamentals, Technologies and Applications*, Second Edition PHI Learning Private Limited, **2011**.
[6] GD Rai, Solar Energy Utilization, Khanna Publishers, Fifth Edition, Seventh Reprint: **2006**.
[7] MD Parmar, RJ Parmar, VR Solanki, RJ Pathak and VM Pathak, The Effect of Global Solar Irradiance on the Electrical Parameters of Multicrystalline Silicon Solar Cell, *International Journal of Emerging Technology and Advanced Engineering*, **2015**, 5(4), 152 – 161.