PERFORMANCE IMPROVEMENT OF PV SOLAR SYSTEM BY DIFFUSED REFLECTION

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DECLARATION

We hereby declare that this thesis is our own work and effort and that it has not been submitted anywhere for any award or any degree. Where contributions of others are involved and they have been acknowledged. Different sources of information have been used that are mentioned by reference. This work has done under the guidance of Dr. Md. Quamrul Ahsan, Professor, Dept. of EEE, BRAC.

Signature of Supervisor

December 7, 2018

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Last but not the least; we would like to thank our friends who expand theirs helping hand in our crisis moment and also our family for supporting us spiritually.

Abstract

Performance of a solar panel depends on how much solar light it can collect. For collecting maximum amount of light we can use reflectors. Through a reflector we significantly improve energy production by means of focusing and increasing more diffused sunlight on the solar cell. This paper will show that, utilizing various types of reflectors at an optimum angle increase the output power of each individual panel in different weather. The reflectors are simpler and designed in cost-effective way and tested. The practical results show good improvement in the performance of the solar system.

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Objective:

- To evaluate efficiency improvement of PV cell by using reflector
- To design and fabricate reflector
- Test the reflector with a PV solar panel in real life

Chapter 1
INTRODUCTION

1.1 Background

The global energy demand is continuously increasing. Today's global energy production is highly, in fact 86% dependent on fossil fuel resources. These resources are limited and their use results the massive climate change through the greenhouse effect and produced large scale environmental pollution. To provide a sustainable power production in future, now-a-days growing demands for energy from renewable resources. The sun is the source of the life on our planet and it is the fuel for most renewable systems. World Production of solar cells increased to **9.34** gig watts (GW) in 2009, a jump of 36% in just previous one year. In the past 28 years till present, solar energy has increased in efficiency and its price levels have improved dramatically. The price of photovoltaic solar cells has decreased from around $27 to a current price of $4 per peak watt. Today the theoretical efficiency of a solar PV cell is said to be around the 25% to 30% mark and a practical efficiency around the17% marked.

PV solar system is becoming more popular with time as a renewable source of electrical energy. The reason behind this increasing popularity is the decreasing capital cost of PV solar panels as well as the increasing concern of the civil society regards the environmental pollution of the waste disposal of the thermal power plants and the impacts of water reservoirs of hydro plants. The solar energy is still more expensive then the classical fossil burned electricity. However, by applying a reflector system for the flat panel, a theory that has been tested and developed that overall output and efficiency can be improved.

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Chapter 1
INTRODUCTION

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No of studies has been done such as those by hossain and aziz[1] to concentrate more intensity of solar radiation flux on to the PV panel, where shiny aluminum and white tiles can produce 15% increasing power output only at a particular time. In that test, they also use mirror which is not much effective because of heat factor. Rizk[2] analyze with different types of reflector like chromium, aluminum, but that is too expensive. Both of the experiments were used four reflectors along with the module, which is much complex and costly. Rahman and Ahmed [3] presented a model with white foam where the angle of reflector was not comprehensible.

All the experiment was done for a limited period. So, for large scale operation, it is critical to design a system for best performance. The present work we have done, extended version of those work and checked the effect of different reflectors on the PV module. The studied shows the performance of PV module at long term observation and economically viable.

1.2 Scenario in Bangladesh:

At present the power demand in Bangladesh is about 5500MW, whereas the generation ranges only 3200-4000MW. The generation capacity is 4300MW. But peak demand is estimated to exceed 5,000 MW. As a result of power shortage causes excessive load shading. Bangladesh relies heavily on fossil fuels for its energy especially on gas resources. But the present proven reserve would be used up by 2015. In Bangladesh the development of renewable energy is insufficient. The one and only hydro power plant is in Karnaphuly can generate 230MW.Power generation from solar energy is controlled by PV so far. The current installed capacity of Solar PV is 15MWe which is only 0.33% of the total power generation.

1.3 Impact of Diffused reflection:

Diffused reflection occurs when light strikes a target and is scattered over a wide angle.

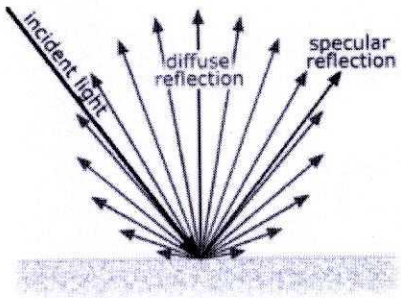

Fig1 : Diffused Reflection

Some of the solar rays reach the Earth's surface directly. Other rays go through reflection and refraction and these are call diffused rays. Normally panel missed these rays. Any solar performance depends on how much solar irradiation it can collect. So, we have to collect diffused rays to increase the efficiency of the panel.

Chapter 2

STATE OF THE ART

Most solar cells manufactured and sold are based on the use of multi crystalline silicon or Mono crystalline silicon with cell and module efficiencies typically in the range 10-16%. Higher efficiencies have been achieved in the laboratory. Although these products have demonstrated excellent stability but they are not cost competitive with other forms of power generation. This has led to much work on reducing production costs, e.g. by light trapping, which leads to the use of thinner silicon, reducing material costs. Amorphous silicon based devices are much cheaper to manufacture compared to the mono crystalline and multi crystalline devices but the stabilized efficiencies of commercial products remain < 10%, even for double junction, triple junction and micro-morph devices. A very interesting development is the HIT cell. This hybridizes amorphous silicon and mono

crystalline/multi crystalline silicon technologies to lower production costs and yet achieve high efficiency devices. GaSb have potential for use in TPV systems. Excellent progress has been made in improving the efficiencies and production processes for producing thin film solar cells based on the use of CdTe and CuGaInSe2. Although these only account for <1% of sales at present they promise significant cost reductions compared to the crystalline silicon technologies. The results do demonstrate that polycrystalline thin films have excellent potential for making solar cells and it may be that other compound semiconductors that do not have these problems can be developed. A most likely further development is that of tandem/multifunction devices as these more fully use the solar spectrum to generate power .By using a stack of cells, wide band gap at the top to progressively narrower energy band gap at the bottom it is possible to minimize both thermal and transmission losses. These result in the loss of 54% of the available power in a single junction silicon solar cell. Although so far most successfully demonstrated with GaAs and GaSb cells (efficiency> 36%) there is particularly good potential for using the tandem concept with thin film devices. commitment of the PV industry to recycling also increases the environmental benefits.

Chapter 3

Construction of PV panel

3.1 Photovoltaic Cells: Converting Photons to Electrons:

The solar cells are called photovoltaic (PV) cells, which as the name implies (photo meaning "light" and voltaic meaning "electricity"), convert sunlight directly into electricity. Photovoltaic cells are made of special materials called semiconductors such as silicon, which is currently used most commonly. Basically, when light strikes the cell, a certain portion of it is absorbed within the semiconductor material. This means that the energy of the absorbed light is transferred to the

semiconductor. The energy knocks electrons loose; efficiencies of approximately 24% in 2000, 26% in 2002, 28% in 2005 and in 2007 have evolved to a 30%

When a photon hits a piece of silicon, one of three things can happen:

1. the photon can pass straight through the silicon — this (generally) happens for lower energy photons,
2. The photon can reflect off the surface,
3. The photon can be absorbed by the silicon, if the photon energy is higher than the silicon band gap value. This generates an electron-hole pair and sometimes heat, depending on the band structure

3.2 Equivalent circuit of a solar cell

In practice no solar cell is ideal, so a shunt resistance and a series resistance component are added to the model. The resulting equivalent circuit of a solar cell is shown below

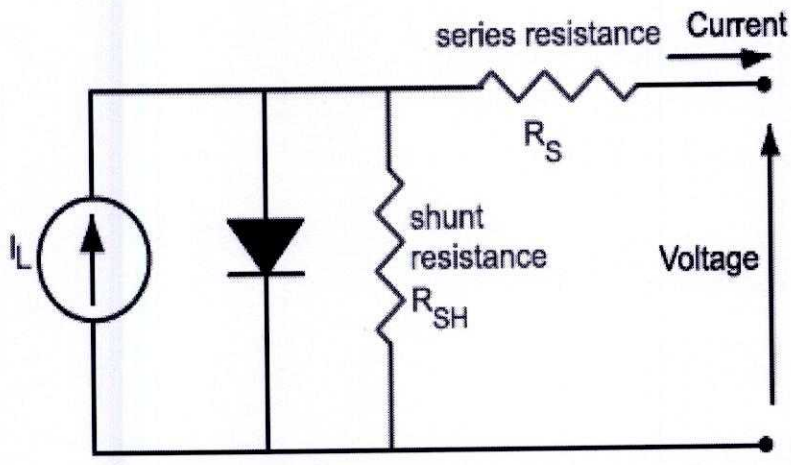

Fig 3.1: Equivalent circuit of a solar cell

3.3 Characteristic equation:-

In the presence of both series and shunt resistances, the IV curve of the solar cell is given by;

$$I = I_L - I_0 \exp\left[\frac{q(V + IR_S)}{nkT}\right] - \frac{V + IR_S}{R_{SH}}$$

Where

- I = output current (amperes)
- I_L = photogenerated current (amperes)
- I_{SH} = shunt current (amperes)

The current through these elements is governed by the voltage across them: where

- V = voltage across the output terminals (volts)
- I = output current (amperes)
- R_S = series resistance (Ω)
- I_0 = reverse saturation current (amperes)

3.4. Open-circuit voltage and short-circuit current

When the cell is operated at open circuit, $I = 0$ and the voltage across the output terminals is defined as the *open-circuit voltage*. Assuming the shunt resistance is high enough to neglect the final term of the characteristic equation, the open-circuit voltage V_{OC} is:

$$V_{OC} \approx \frac{kT}{q} \ln\left(\frac{I_L}{I_0} + 1\right).$$

Similarly, when the cell is operated at short circuit, $V = 0$ and the current I through the terminals is defined as the *short-circuit current*. It can be shown that for a high-quality solar cell (low R_S and I_0, and high R_{SH}) the short-circuit current I_{SC} is:

$$I_{SC} \approx I_L.$$

The short-circuit current is due to the generation and collection of light-generated carriers. For an ideal solar cell at most moderate resistive loss mechanisms, the

short-circuit current and the light-generated current are equal. Therefore, the short-circuit current is the largest current which may be drawn from the solar cell.

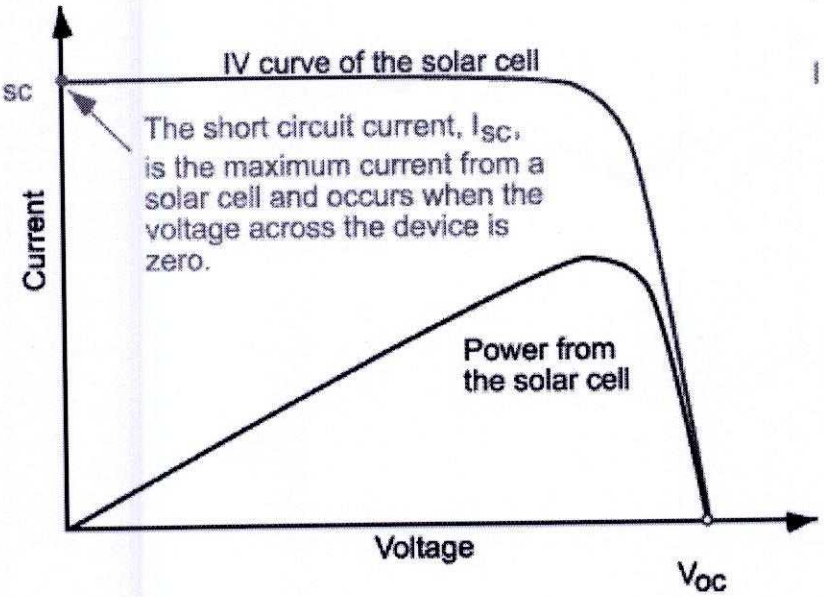

Fig 3.2 : IV Characteristic curve of a Solar cell

3.5 Cost and Efficiency of a Solar panel

As a result of increases in solar panel production and technologies the cost of solar cells has dropped dramatically, even as efficiencies are rising. Companies are engaged in a race to ramp up production, obtain financing and to emerge as the dominant players in the solar market. Between 2009 and 2010, costs per watt in production, has dropped by about 15%. The race between emerging markets such as thin film solar, and established high density solar panel markets is on.

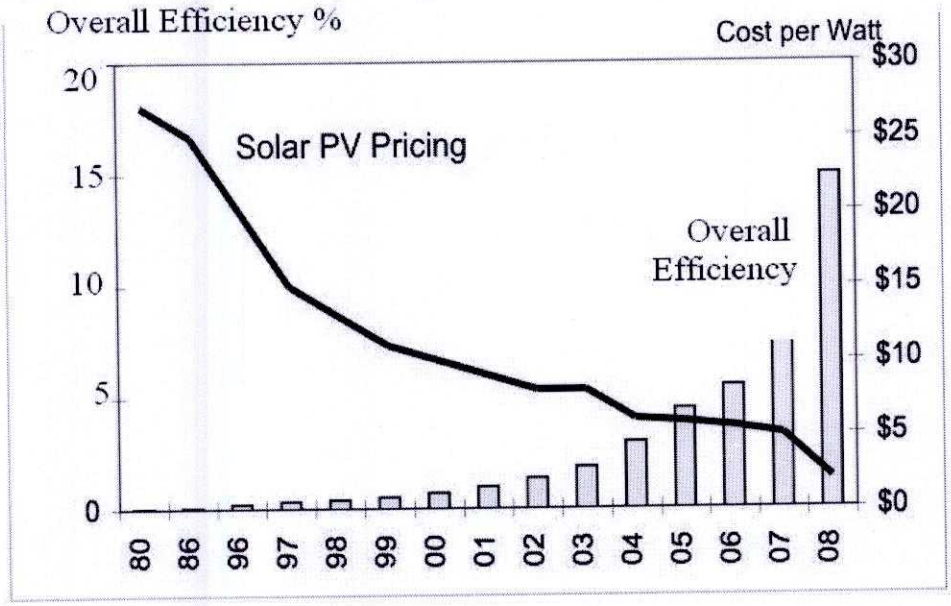

Fig 3.3 : Efficiency and Cost Curve of PV solar cell

The cost of solar is becoming attractive compared to other power plant solutions such as those of fossil fuels such as oil, gas and coal. As extraction costs rise for traditional power solutions, the cost of solar power solutions is dropping dramatically. The PV cell is a strong candidate for an eventual replacement to other forms of power generation.

Chapter 4

Practical work

4.1 Experimental Setup:

Table:4. 1 Rating of Solar Panel:

Maximum Power Output, Pmax[W]	5.00 watt
Open Circuit Voltage, Voc [v]	26.70
Short Circuit Current, Isc [A]	0.30
Nominal Operating Voltage, Vdc [V]	12
Protection class,	class II
Cell type	mono-crystalline

Equipments:

1. Solar panel
2. Multi meter
3. Reflectors
4. Stands (**45°, 55°, and 65°**)

4.2 Proposed method:

Reflectors are used to increase the amount of solar energy striking the modules. Since reflectors cost less than photovoltaic modules, this method may be used for improve the efficiency in cost-effective way. By designing a reflector system onto the panel, we have to consider the heat factor. Reflector not only increases the

amount of sunlight onto the panel but also produced excessive heat. Therefore we couldn't use mirror as a reflector into our system.

4.3 Types of Reflector:

In our research we have incorporated 4 types of reflector

1) White Foam Reflector
2) Stainless Steel Reflector
3) Aluminum Reflector and
4) Standard Reflector

The dimensions of the reflector are 11"X9" and widths of the reflector were same as the solar cell side. This allows that any sunlight hitting the top, bottom or center of the reflector, will reflect onto the panel at the opposite point. By testing these reflectors we can determine which type of reflector will be both efficient, practical and do not produce excess heat.

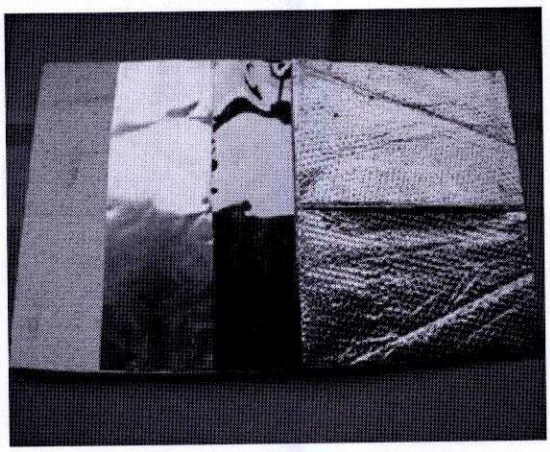

Fig4.1: **Various types of reflectors**

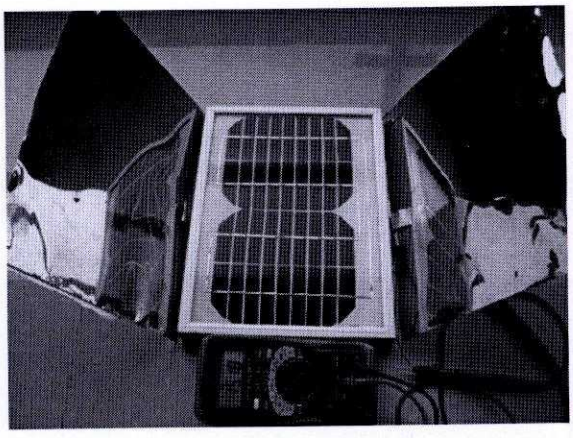

Fig4.2: **Solar panel with reflector**

The maximum power output rating (Pmax) of the solar panel was 5.00watt. The cell type is mono-crystalline. But the thickness and price varies a little bit which are given below

Table 4.2: Thickness and price of different Reflectors

Types of Reflector	Thickness	Price (per sq-feet)
White Foam	3mm	BDT 40.00
Aluminum	0.25mm	BDT 60.00
Stainless Steel	0.35mm	BDT 100.00
Standard Reflector	0.30mm	BDT 150.00

Chapter 5
Results

To influence the output power by diffused reflection were used with the solar panel. The solar panel was aligned horizontally in the north-south direction. The reason behind this kind of placing is to utilize the maximum area of the panel for diffused reflection. Reflectors were placed on the east-west side of the solar panel at 3 different angles of approximately **45°, 55°, and 65°**. Sunny and cloudy weather condition was considered during this project.

In a sunny day and cloudy day we measured the Voc and Isc of the solar panel with multi meter.

The data is given below in Table.

DATE-9.07.10

Table5.1 Solar Panel data (Sunny day)

Time	Voc	Isc	Power, P	Weather condition
8.00	19.20	0.19	3.648	Sunny
8.30	19.80	0.231	4.5738	Sunny
9.00	19.40	0.270	5.238	Sunny
9.30	19.31	0.250	4.8275	Sunny
10.30	19.50	0.308	6.006	Sunny
11.00	19.30	0.314	6.0602	Sunny
11.30	19.05	0.302	5.7531	Sunny
12.30	18.94	0.329	6.2313	Sunny
1.00	18.48	0.295	5.452	Sunny
2.30	19.50	0.249	4.8555	Sunny
3.00	19.21	0.250	4.8025	Sunny
4.30	18.65	0.103	1.9209	Sunny
5.30	17.7	0.04	0.708	Sunny
6.30	13.10	0.002	0.0262	Sunny
6.40	10.0	0.00	0.00	Sunny

Maximum Open Circuit Voltage, Voc = 19.80 V
Maximum Short Circuit Current, Isc = 0.231 A
Maximum Power, Pmax = 6.2313 watt

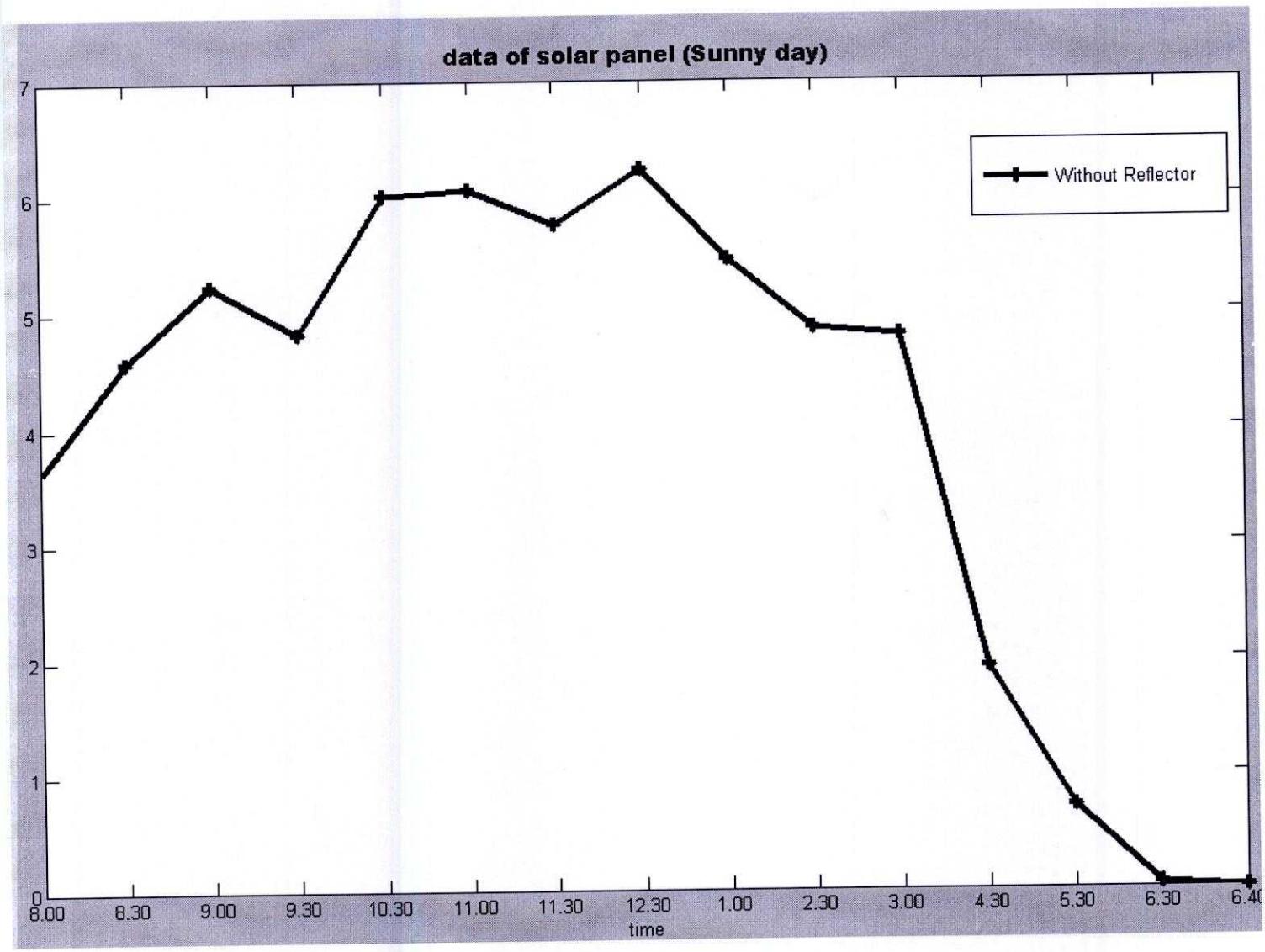

Fig5.1: Power Vs time curve of a Solar panel (Sunny)

DATE-06.08.2010
Day-FRIDAY
Table 5.2: **Solar Panel data (Cloudy day)**

Time	Voc	Isc	Power, P	Weather
8.00	13.91	0.004	0.056	cloudy
8:30	14.09	0.009	0.085	cloudy
9:30	14.57	0.009	0.131	cloudy
10:15	16.06	0.012	0.193	cloudy
11.00	16.36	0.010	0.163	cloudy
12:00	16.78	0.016	0.268	cloudy
01:00	17.99	0.022	0.396	cloudy
02:00	17.78	0.032	0.569	cloudy
03:00	17.38	0.028	0.486	cloudy
03:45	13.24	0.003	0.039	cloudy
04:30	15.91	0.009	0.143	cloudy
05:30	16.60	0.015	0.249	cloudy
06.15	10.57	0.000	0.000	cloudy
06.30	09.58	0.000	0.000	cloudy

Maximum Open Circuit Voltage, Voc = 18.28
Maximum Short Circuit Current, Isc = 0.038
Maxium Power, Pmax = 0.681

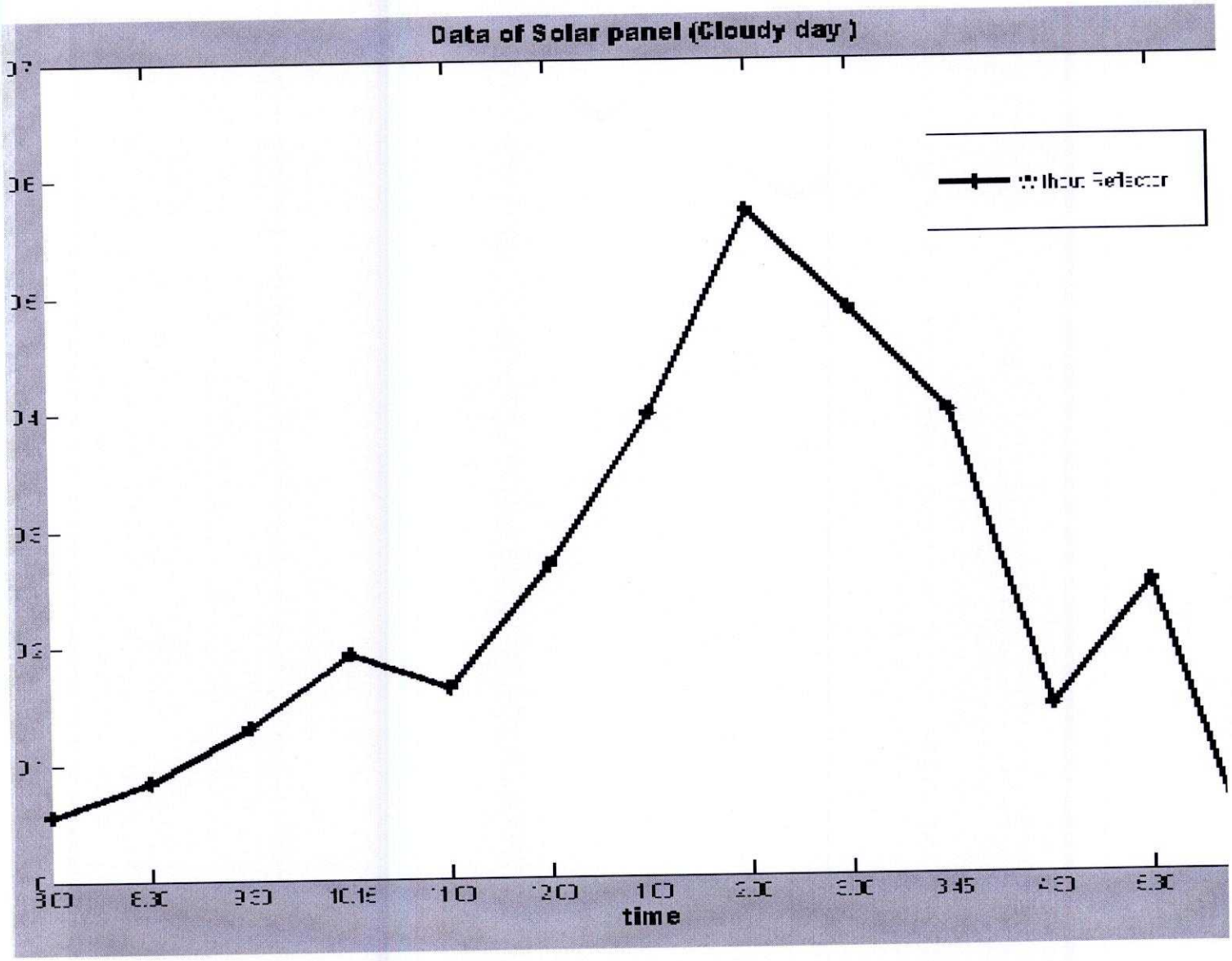

Fig5.2: Power Vs time curve of a Solar panel (Cloudy)

5.1 Best angle :

One of the important factors that affect the efficiency of a PV panel is angle. In our experiment the solar panel was aligned at a fixed angle of 23.5 with the horizontal. The angle between the panel and reflector are important factors that affect the efficiency of the system. If the panel is pointing directly at the light source, then the best angle to place the reflector is not 45°, but between 45 and 65, depending on the reflector size. We get maximum output when the reflector was at an angle of 55°.

We collect the data at 55 angle of Aluminum reflector and compare its data with the data of solar panel. And we observed that output power is increased by using aluminum reflector in both sunny and cloudy weather.

DATE-9.07.10
Day-: Friday
Angle: 55

Table 5.3: Comparing Solar panel and Aluminum reflector at 55°

Time	Without Reflector, Power, P	Aluminum, Power, P	(%) power output increase using Aluminum	Weather
8.00am	3.648	4.555	22.6312	Sunny
8:30am	4.5738	5.161	4.0207	Sunny
9:30am	5.238	5.0235	-2.3635	Sunny
10:15am	4.8275	5.4414	5.1227	Sunny
11.00am	6.006	7.4295	12.013	Sunny
12:00pm	6.0602	6.7521	7.8314	Sunny
01:00pm	5.7531	7.9397	16.495	Sunny
02:00pm	6.2313	8.5495	7.4575	Sunny
03:00pm	5.452	6.5278	7.006	Sunny
03:45pm	4.8555	5.1391	5.1673	Sunny
04:30pm	4.8025	4.8362	-8.3103	Sunny
05:30pm	1.9209	1.9822	12.624	Sunny
06.15pm	0.708	1.5795	2.189	Sunny
06.30pm	0.0262	0.0244	-3.8931	Sunny
7.00 pm	0.00	0.00	0.00	Sunny

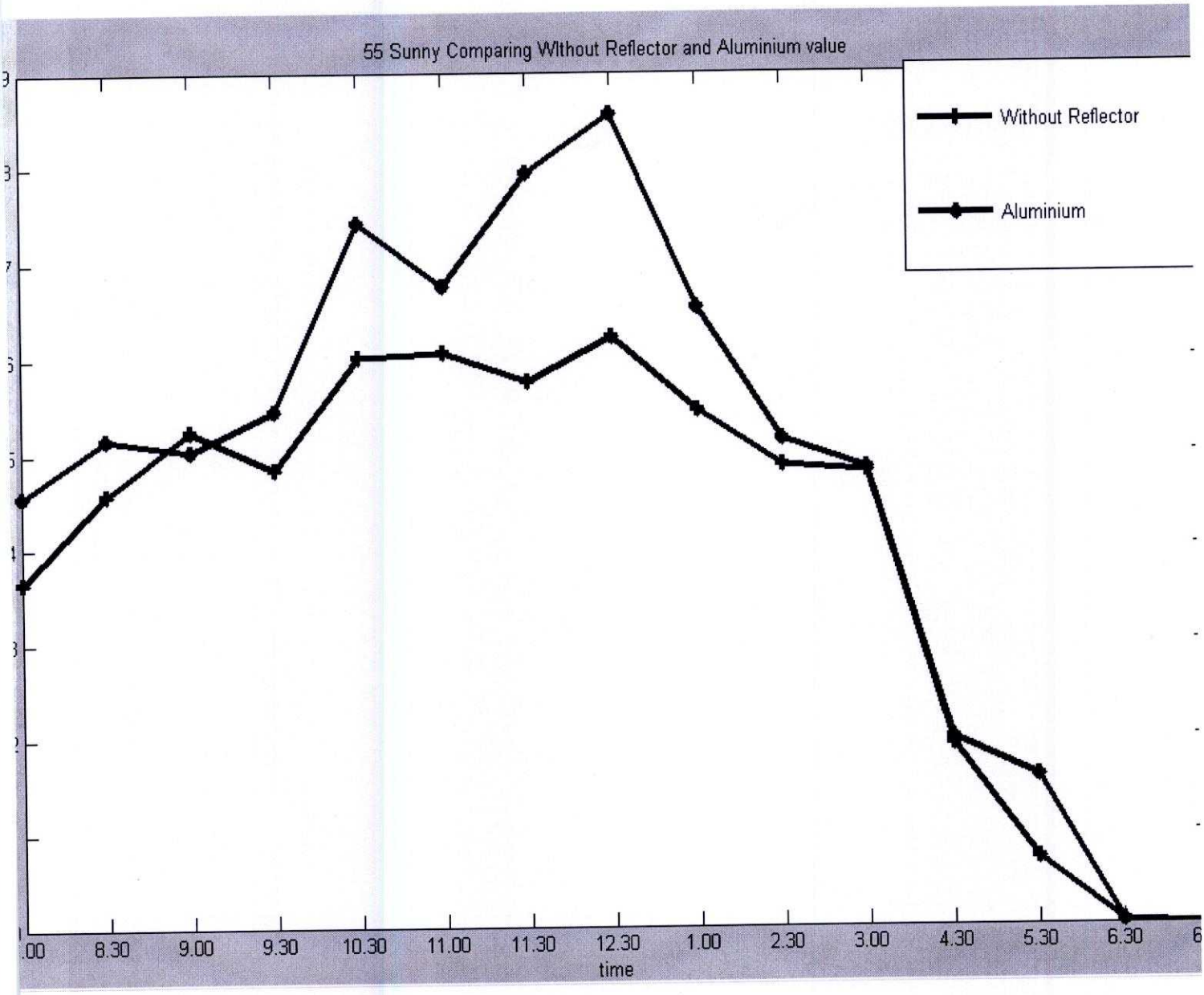

Fig 5.3: <u>Comparing Solar panel and Aluminum reflector at 55° (Sunny)</u>

DATE-06.08.10
Day-: Friday
Angle: 55
Table: 5.4: Comparing Solar panel and Aluminium reflector at 55°

Time	Power (watt) without Reflector	Power (watt) with Aluminum Reflector	Power output increase(%)	Weather
8.00am	0.056	0.0706	26.07	Cloudy
8:30am	0.085	0.10024	18.627	Cloudy
9:30am	0.131	0.131	-0.099	Cloudy
10:15am	0.193	0.212	10.004	Cloudy
11.00am	0.163	0.222	36.196	Cloudy
12:00pm	0.268	0.269	0.089	Cloudy
01:00pm	0.396	0.512	29.308	Cloudy
02:00pm	0.569	0.681	19.757	Cloudy
03:00pm	0.486	0.485	-0.288	Cloudy
03:45pm	0.397	0.57	43.57	Cloudy
04:30pm	0.143	0.146	0.699	Cloudy
05:30pm	0.249	0.283	13.65	Cloudy
06.15pm	0.000	0.000	0.000	Cloudy
06.30pm	0.000	0.000	0.000	Cloudy

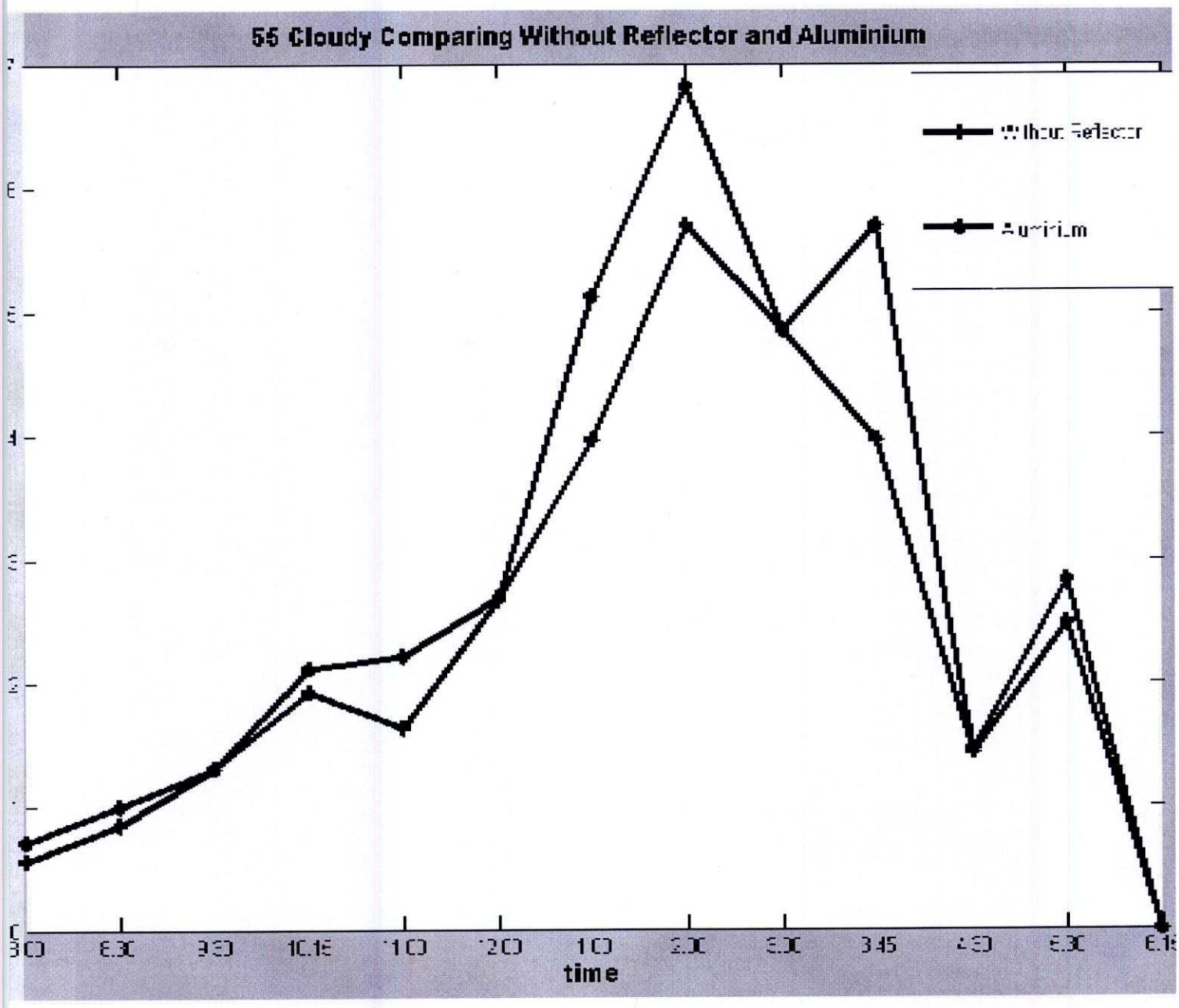

Fig 5.4: Comparing Solar panel and Aluminum reflector at 55° (Cloudy)

5.2 Comparing 4 types of Reflector:

Throughout the day we compare 4 types of reflector. These tests have done both in sunny day and cloudy day.

DATE-10.10.10
Day-Monday

Table5.5 : Power Output comparison of all Reflectors at 55° (Sunny)

Time	Power (watt) without Reflector	Power (watt) with Aluminum Reflector	Power output increase(%)	Power (watt) with White Foam Reflector	Power output increase(%)	Power (watt) with Stainless Steel Reflector	Power output increase(%)	Power (watt) with Standard Reflector	Power output increase(%)
8.00	0.16	0.21	31.25	0.21	31.25	0.16	0.00	0.16	0.00
9:00	0.22	0.24	9.09	0.24	1.78	0.24	`1.78	0.24	1.78
10:00	0.29	0.31	6.89	0.33	13.79	0.29	0.00	0.31	6.89
10:30	1.61	1.55	-3.73	1.54	-4.34	1.61	0.00	1.68	4.35
11.00	2.57	1.64	-36.19	1.64	-36.19	2.20	-14.39	2.01	-21.79
12:00	3.02	3.03	0.33	2.83	-6.29	3.02	0.00	3.41	12.91
12:30	4.42	4.99	12.89	5.40	22.17	4.82	9.05	4.99	12.89
01:00	4.23	5.00	18.20	4.82	13.95	4.43	4.73	5.00	18.20
02:00	4.01	4.42	10.22	4.42	10.22	5.37	33.91	4.03	0.49
03:00	3.28	3.28	0.00	3.32	1.22	3.08	-6.09	3.27	-0.30
03:30	0.21	0.28	33.34	0.28	33.34	0.23	9.52	0.26	23.81
04.30	0.11	0.11	0.00	0.11	0.00	0.13	18.18	0.13	18.18
05.00	0.03	0.03	0.00	0.04	33.30	0.03	0.00	0.03	0.00
05:30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

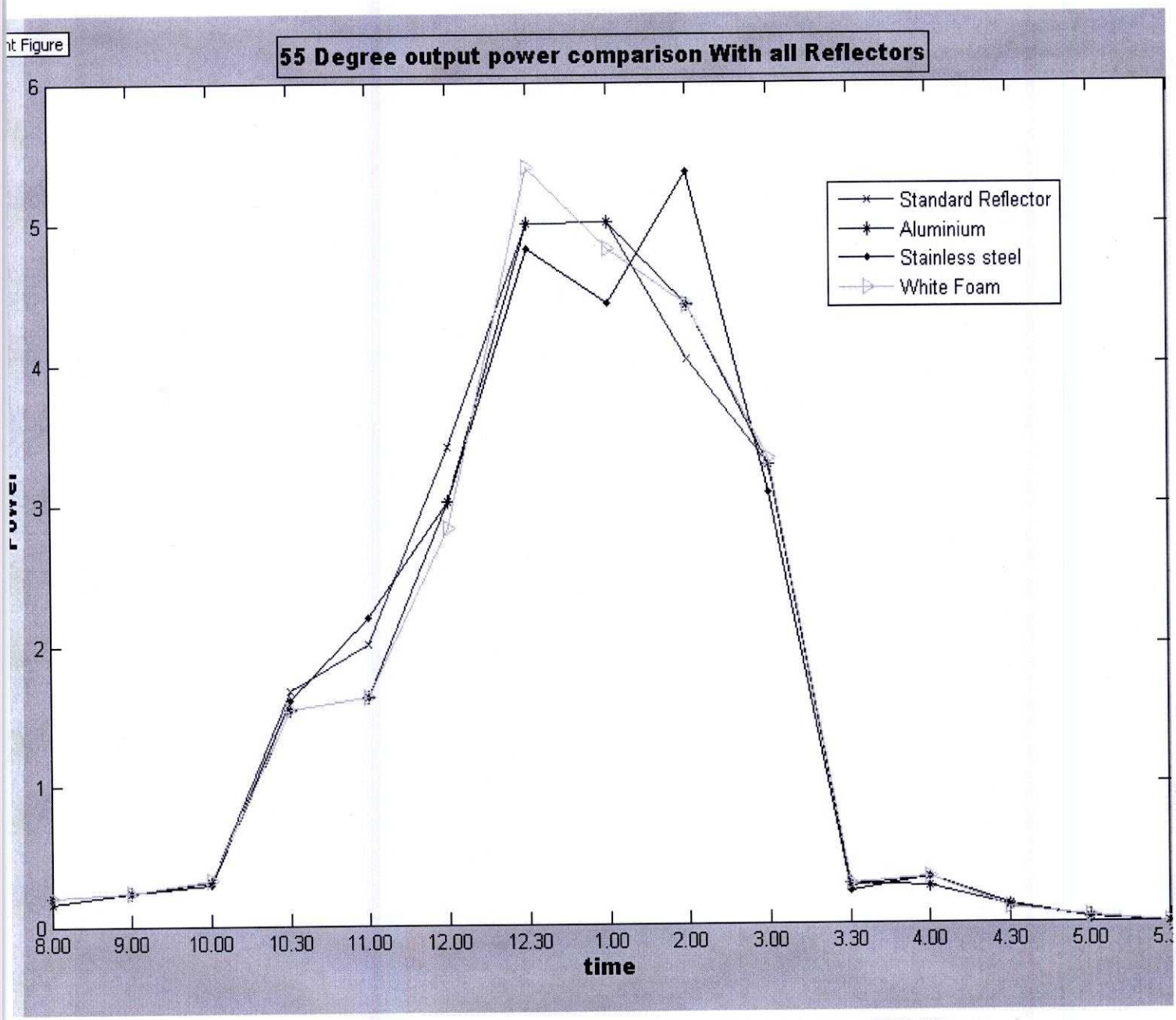

Fig 5.5: Output power comparison of all Reflectors at 55° (Sunny)

Date: 01-11-2010
Day: Monday
Table 5.6 : Power Output comparison of all Reflectors at 55° (Cloudy)

Time	Power (watt) without Reflector	Power (watt) with Aluminum Reflector	Power output	Power (watt) with White Foam Reflector	Power output	Power (watt) with Stainless Steel Reflector	Power output	Power (watt) with Standard Reflector	Power output
8.30	0.0917	0.0916	-0.109	0.0919	0.218	0.0919	0.218	0.0921	0.436
9:00	0.1711	0.1996	16.657	0.1999	16.832	0.1824	6.604	0.1825	6.663
10:00	0.2207	0.2207	0.000	0.2206	0.045	0.2201	-0.272	0.2206	-0.045
11.00	0.202	0.203	0.495	0.203	0.495	0.203	0.495	0.203	0.495
12:00	0.3885	0.3876	-0.232	0.3694	-4.916	0.3879	-0.154	0.3874	-0.283
01:00	0.1457	0.1458	0.069	0.1464	0.480	0.1465	0.549	0.1631	11.942
02:00	0.0945	0.0947	0.212	0.1114	17.884	0.0952	0.741	0.0952	0.741
03:00	0.0584	0.0586	0.342	0.059	1.027	0.0589	0.856	0.0590	1.027
03:30	0.0588	0.0587	-0.170	0.0588	0.000	0.0588	0.000	0.0588	0.000
04:00	0.0428	0.0428	0.000	0.0429	0.234	0.0574	34.112	0.0429	0.234
05.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

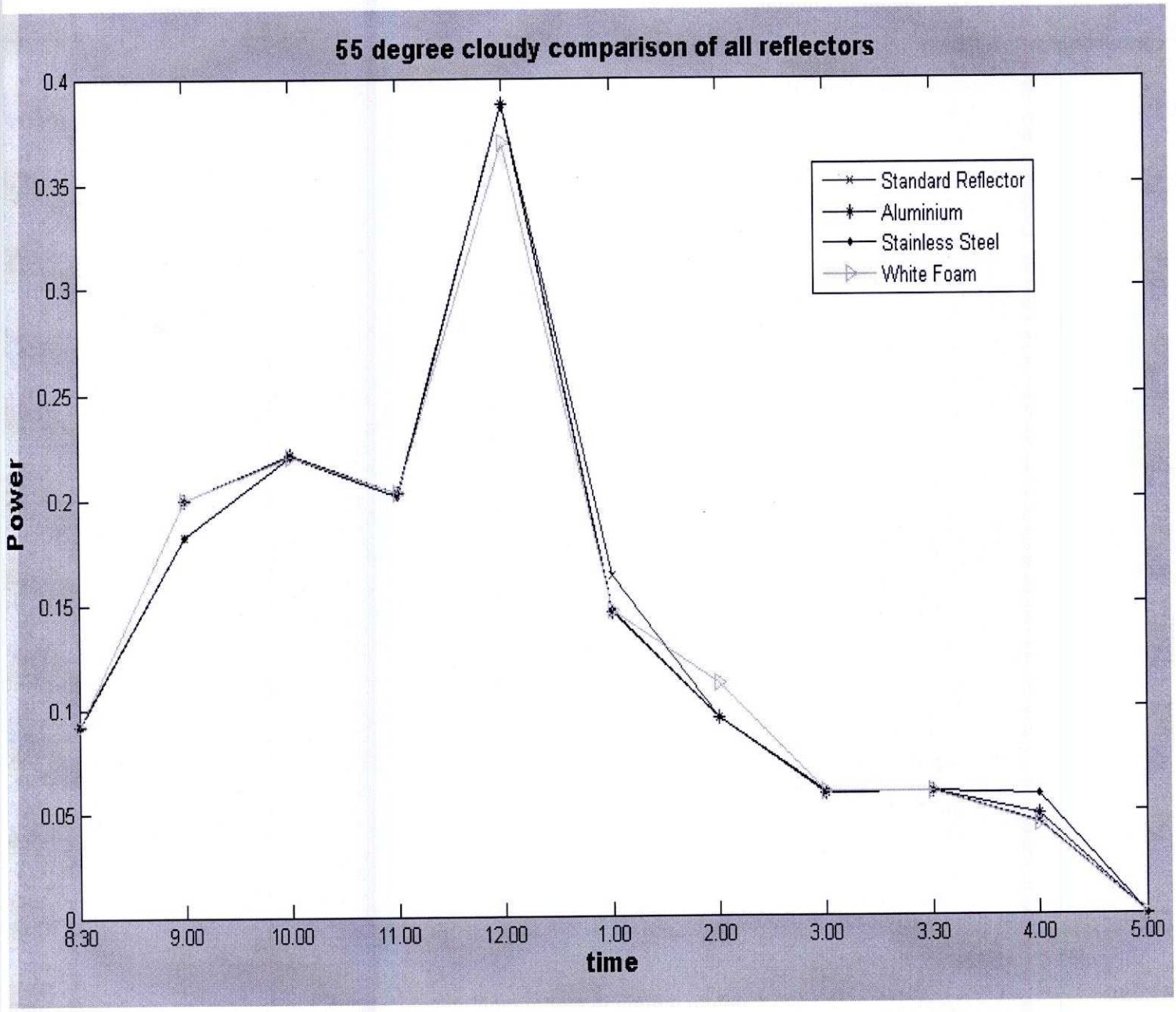

Fig 5.6: Output power comparison of all Reflectors at 55° (Cloudy)

5.3: Reflect of overall Field work:

For our project we not only collect the value of 55°. To get a good observation and for comparing the value of 55°, we measure the value at 45° and also at 65° both in sunny and cloudy weather.

5.4: At 45° angle:

5.4.1 : comparing the solar panel data with a reflector

DATE-9.07.10
Day- Friday
Angle: 45 degree
Weather: Sunny

Table 5.7 : Comparing Solar panel and Aluminum reflector at 45° (Sunny)

Time	Without Reflector, Power, P	Aluminum, Power, P	% increase using Aluminum
8.00	0.186	0.294	**58.06**
9.00	0.275	0.275	**0.00**
10.00	0.317	0.437	**37.85**
10.45	5.875	6.105	**3.91**
11.30	4.814	4.984	**3.62**
11.45	4.725	5.897	**24.67**
12.30	5.76837	5.772	**0.069**
1.15	7.0575	6.7308	**-4.63**
2.00	5.84166	7.155	**22.48**
2.45	4.03	6.052	**50.12**
3.30	4.17	6.082	**45.85**
4.30	4.385	5.71	**29.99**
5.15	0.445	0.424	**-4.72**
5.45	.2132	0.229	**7.512**
6.00	0.0923	0.124	**34.35**
6.30	0.011	0.011	**-0.45**
7.00	0.00	0.00	**0.00**

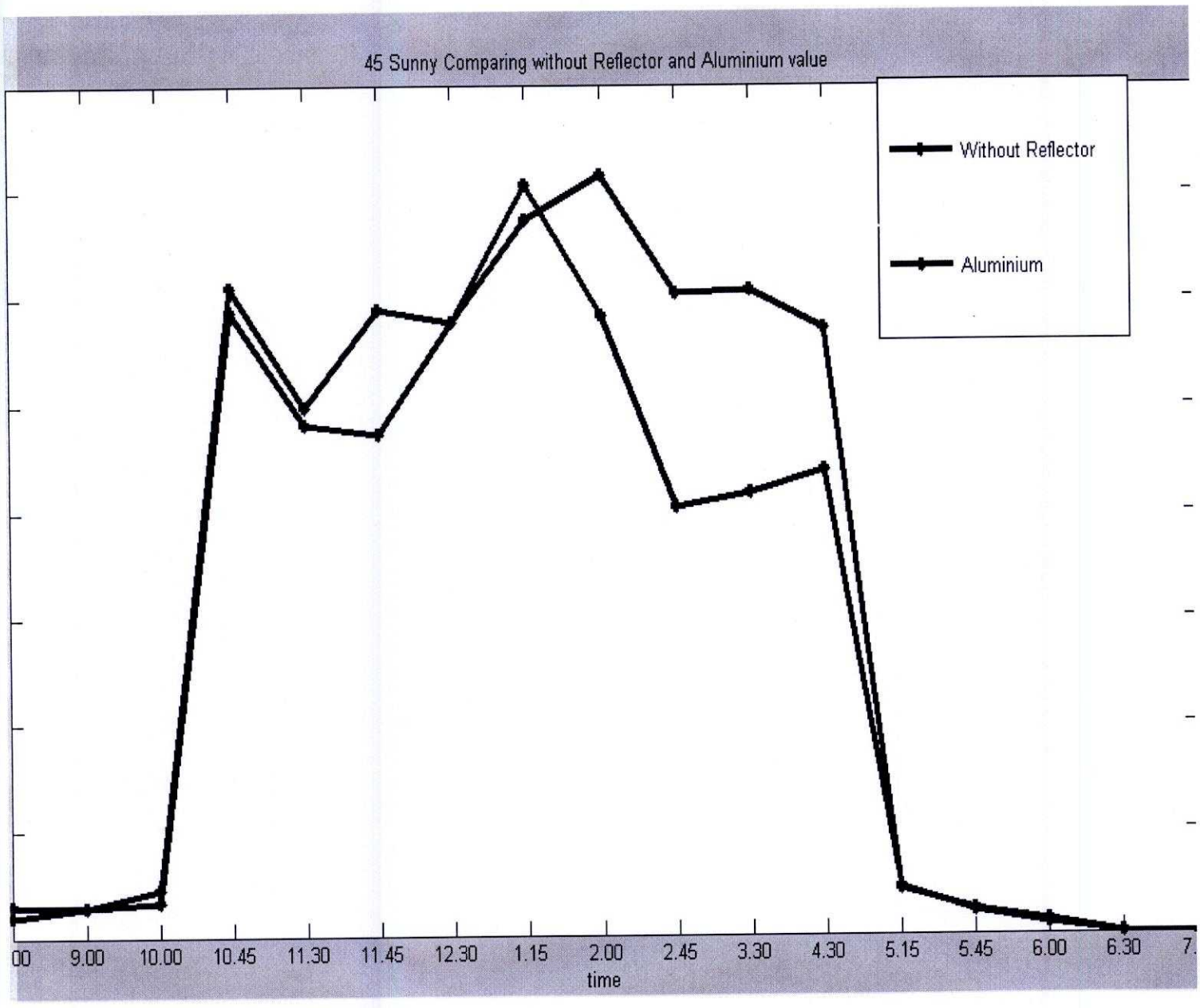

Fig 5.7: <u>Comparing Solar panel and Aluminum reflector at 45° (Sunny)</u>

DATE-16.07.10
Day-Friday
Angle – 45 degree
Weather - Cloudy

Table 5.8 : Comparing Solar panel and Aluminum reflector at 45° (Cloudy)

Time	Without Reflector, Power, P	Aluminium, Power, P	% increase using Aluminium
8.30 AM	0.1858	0.294	**58.23%**
9.15 AM	0.2899	0.2903	**0.138%**
10.00 AM	0.3165	0.4365	**37.91%**
11.15 AM	0.5177	0.6429	**24.18%**
12.00 PM	0.2723	0.3083	**13.22%**
1.00 PM	0.9629	1.4248	**47.97%**
2.45 PM	0.8123	1.201	**47.85%**
3.30 PM	0.4174	0.6082	**45.71%**
4.15 PM	0.4385	0.5707	**30.15%**
5.00 PM	0.4445	0.4236	**-4.701%**
5.45 PM	0.2132	0.2293	**7.55%**
6.15 PM	0.0923	0.1236	**33.91%**
6.45 PM	0.0111	0.0110	**-0.901%**
7.00 PM	0.000	0.000	**0.00%**

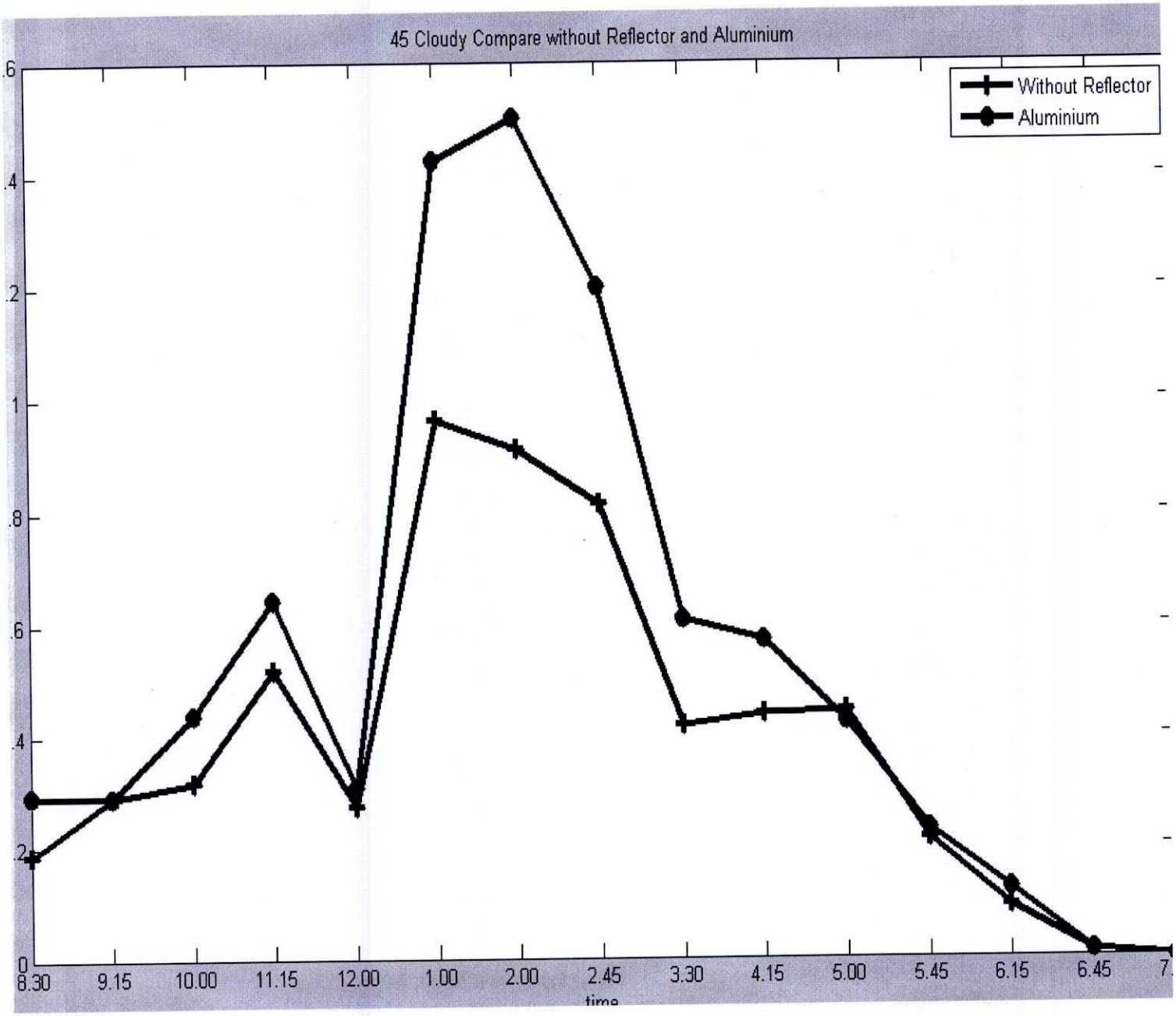

Fig 5.8: Comparing Solar panel and Aluminum reflector at 45° (Cloudy)

5.4.2: Comparing 4 types of Reflector:

DATE-19.07.10
Day-Monday
Angle: 45 degree
Table 5.9 : Power Output comparison of all Reflectors at 45° (Sunny)

Time	Power (watt) without Reflector	Power (watt) with Aluminium Reflector	Power output(%)	Power (watt) with White Foam Reflector	Power output	Power (watt) with Stainless Steel Reflector	Power output	Power (watt) with Standard Reflector	Power output
8.00	0.18	0.19	5.55	0.16	-11.11	0.19	5.56	0.16	-11.11
9:00	0.27	0.31	14.81	0.31	14.81	0.27	0.00	0.30	11.11
10:00	1.46	1.38	-5.48	1.42	-2.74	1.48	1.37	1.42	-2.74
10:30	5.75	5.37	-6.61	5.76	0.17	5.96	3.65	5.75	0.00
11.00	5.84	5.89	0.86	5.87	0.51	5.84	0.00	5.86	0.34
12:00	5.33	5.43	1.88	5.43	1.88	5.51	3.38	5.42	1.69
12:30	4.38	4.40	0.46	4.40	0.46	4.39	0.23	4.40	0.46
01:00	6.19	6.14	-0.81	6.16	0.48	6.16	0.48	6.16	0.48
02:00	5.63	5.65	0.36	5.65	0.36	5.59	-0.71	5.55	-1.42
03:00	3.76	3.68	-2.13	3.68	-2.13	3.64	-3.19	3.68	-2.13
03:30	0.95	0.99	4.21	0.97	2.11	0.97	2.11	0.96	1.05
04:00	0.33	0.38	15.15	0.35	6.06	0.34	3.03	0.35	6.06
04.30	0.14	0.14	0.00	0.14	0.00	0.14	0.00	0.14	0.00
05.00	0.05	0.07	40.00	0.07	40.00	0.05	0.00	0.05	0.00
05:30	0.01	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00

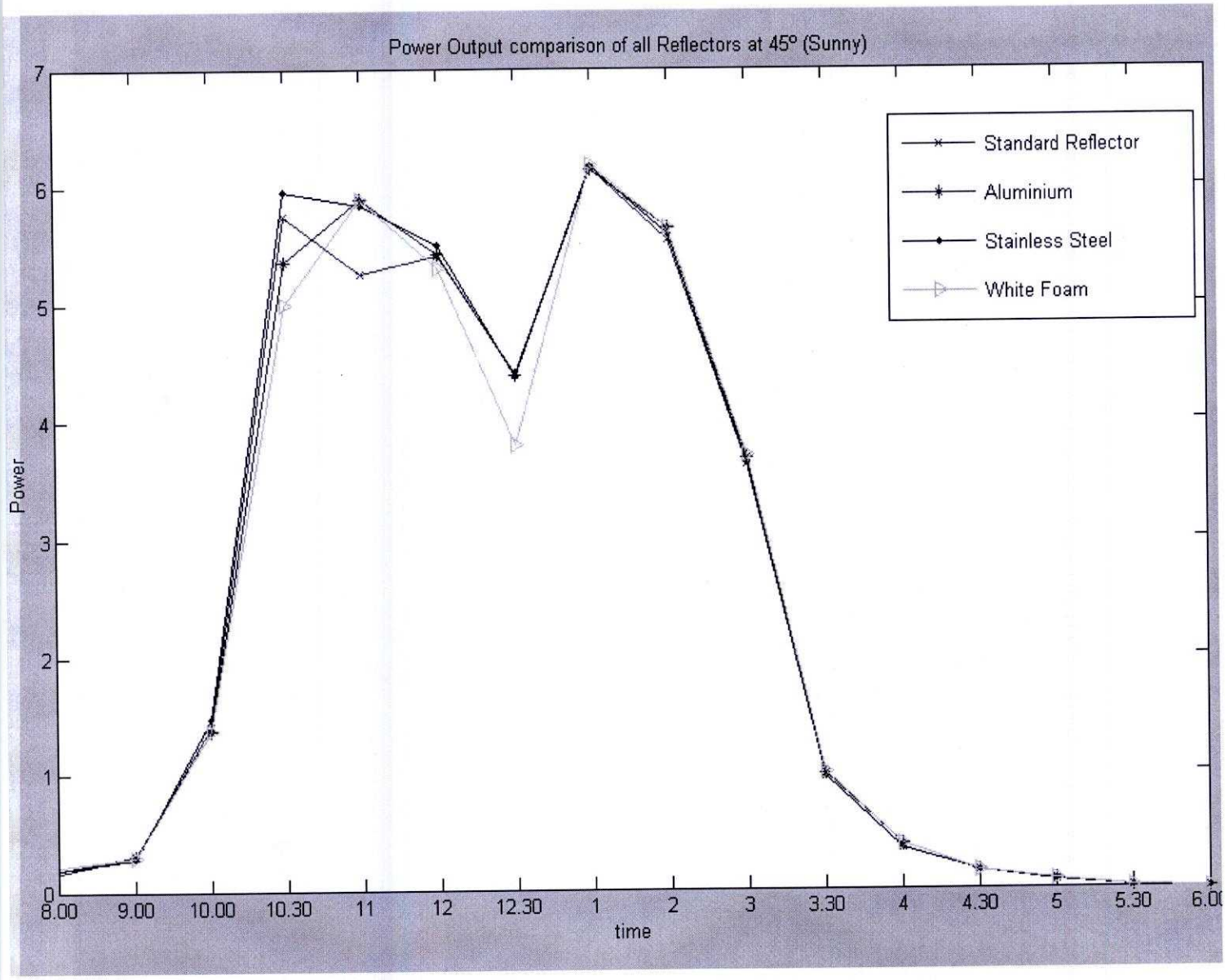

Fig 5.9: Output power comparison of all Reflectors at 45° (Sunny)

Date: 31-10-2010
Angle- 45
Weather: cloudy

Table 5.10 : Power Output comparison of all Reflectors at 45° (Cloudy)

Time	Power (watt) without Reflector	Power (watt) with Aluminium Reflector	Power output (%)	Power (watt) with White Foam Reflector	Power output (%)	Power (watt) with Stainless Steel Reflector	Power output (%)	Power (watt) with Standard Reflector	Power output (%)
8.30	0.2374	0.2377	0.1264	0.2568	8..1786	0.2562	7.919	0.2562	7.919
9:00	0.139	0.1472	5.899	0.1306	-6.043	0.1473	5.9712	0.1303	-6.259
10:00	0.3105	0.3105	0.000	0.3476	11.948	0.3285	5.7971	0.3289	5.925
11.00	0.2183	0.2365	8.337	0.2187	0.183	0.2537	16.216	0.2363	8.246
12:00	0.3857	0.4046	4.900	0.4229	9.645	0.4226	9.567	0.4048	4.952
01:00	2.0995	2.1216	1.0526	2.0984	-0.0524	2.1227	1.105	2.1204	1.000
01:30	1.9883	2.009	1.0411	2.0295	2.0721	2.0111	1.147	2.0284	2.0168
02:30	1.3036	1.3623	4.503	1.383	6.0908	1.3616	4.449	1.3838	6.152
03:30	0.1542	0.1385	-10.18	0.1543	0.065	0.1387	-10.052	0.1549	0.454
04:30	0.0533	0.0669	25.51	0.0534	0.1876	0.0533	0.000	0.0534	0.1876
05.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

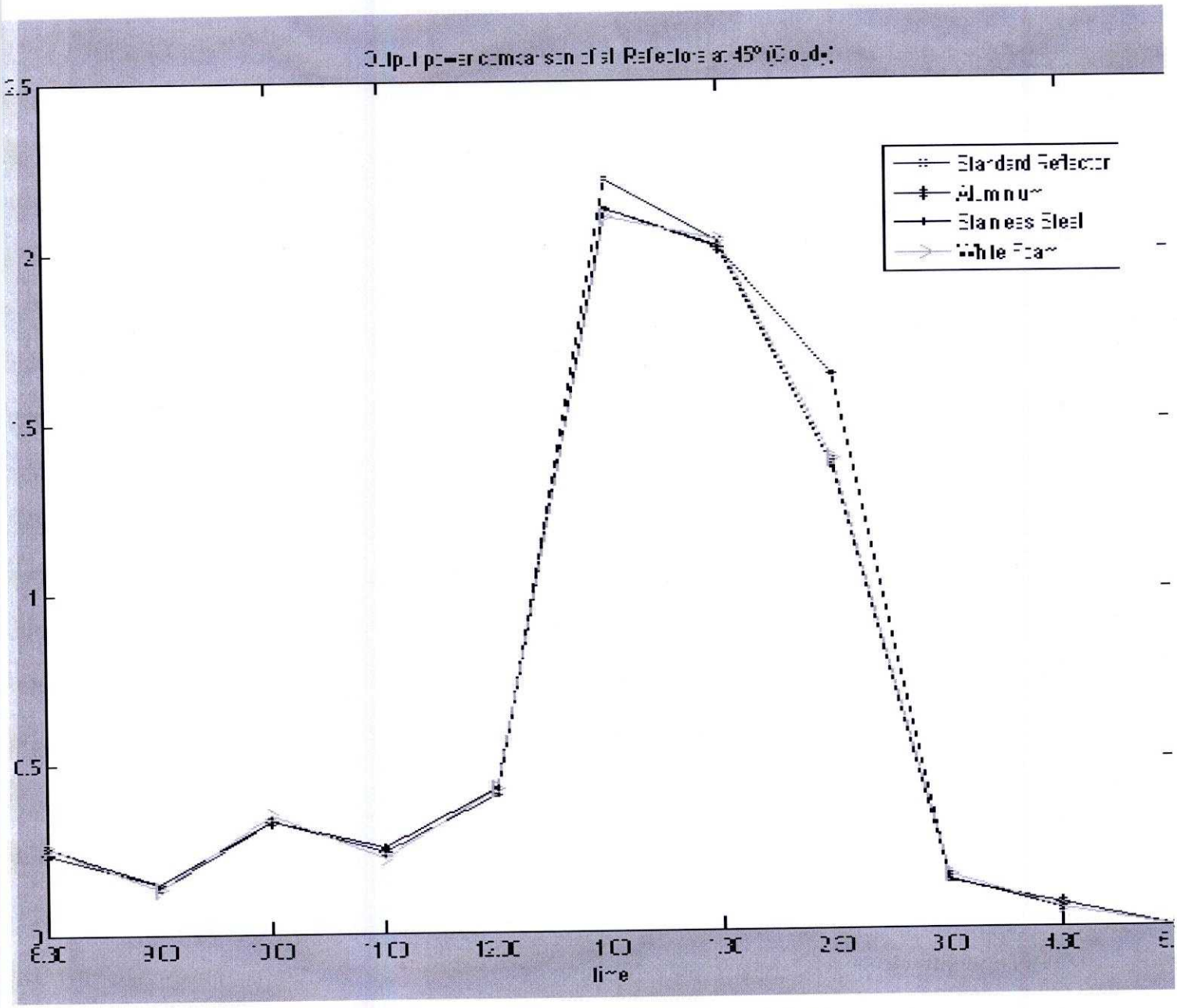

Fig 5.10: Output power comparison of all Reflectors at 45° (Cloudy)

5.5: At 65° angle:

5.5.1 : comparing the solar panel data with a reflector

DATE-23.07.10
Angle: 65 degree
Weather: Sunny
Table 5.11 : Comparing Solar panel and Aluminum reflector at 65° (Sunny)

Time	Power(Watt) Without reflector	Power(Watt) Reflector-Aluminum	%Increase
8.00	2.162	2.213	2.35%
8.30	2.775	2.81	1.26%
9.00	2.4388	2.434	-0.109%
9.30	4.8275	4.8275	0%
10.00	4.914	4.934	0.41%
11.00	5.646	6.644	17.68%
12.00	4.315	6.553	51.87%
1.00	5.362	6.288	17.27%
2.00	4.3631	4.598	5.38%
3.00	4.1419	4.277	3.26%
4.00	1.827	1.954	6.95%
4.45	1.257	0.922	-26.65%
5.30	0.439	0.438	-0.228%
6.00	0.0196	0.02	2.04%
6.30	0.00	0.00	0%

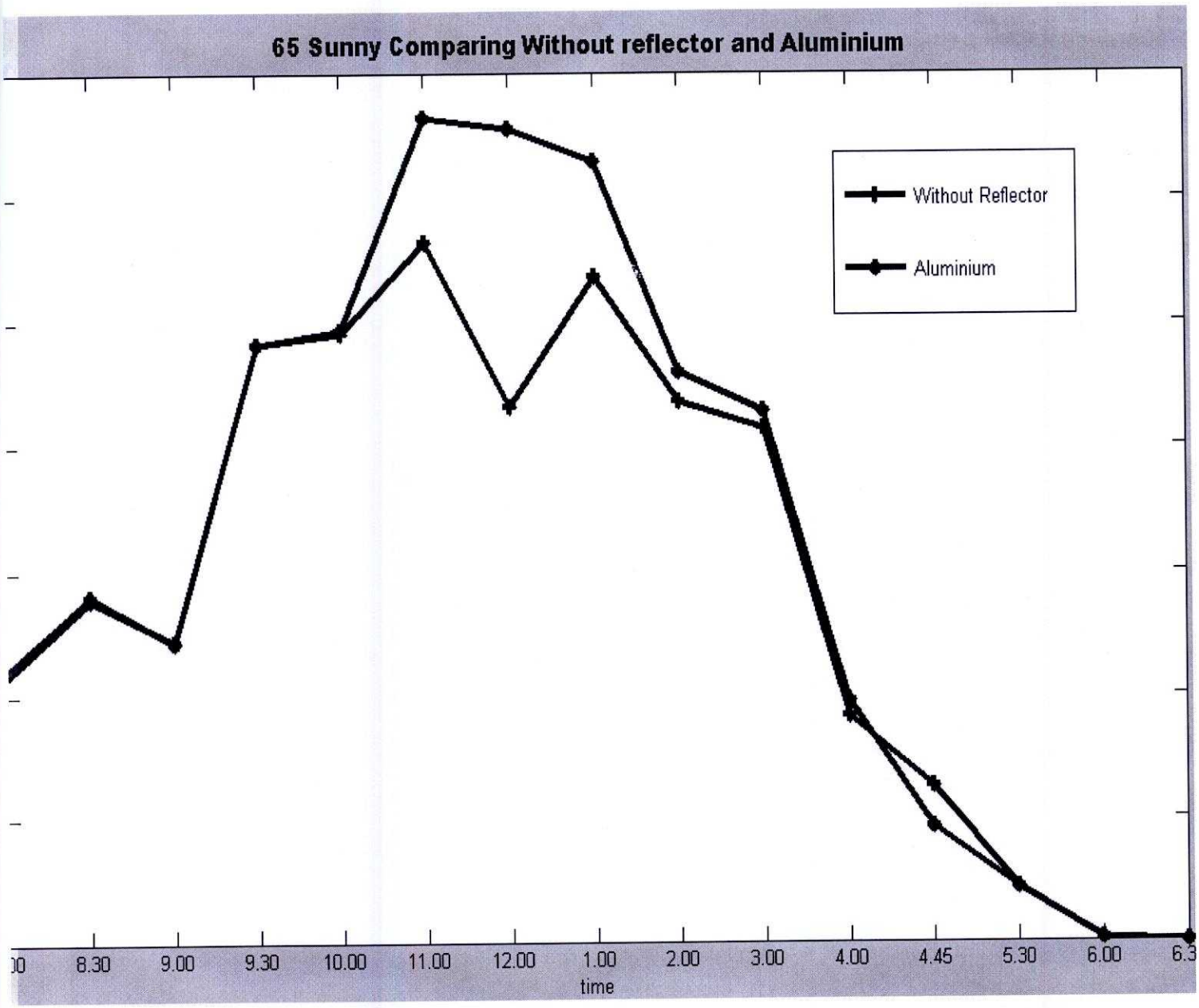

Fig 5.11: Comparing Solar panel and Aluminum reflector at 65° (Sunny)

DATE-24.07.10
Angle: 65 degree
Weather: Cloudy

5.12 : Comparing Solar panel and Aluminum reflector at 65° (Cloudy)

Time	Power(Watt) Without reflector	Power(Watt) Reflector-Aluminum	%Increase
8.00 AM	0.895	0.954	6.592%
8.30 AM	1.0082	1.07	5.776%
9.00 AM	1.799	1.999	10.025%
9.45 AM	3.68	3.8	3.261%
10.30 AM	2.29	2.61	13.974%
11.15 AM	2.26	2.244	-0.713%
12.30 PM	1.49	1.71	14.765%
2.15 PM	1.082	1.21	11.83%
2.45 PM	1.39	1.39	0.000%
3.30 PM	1.31	1.46	11.450%
4.30 PM	0.86	0.88	2.326%
5.00 PM	0.77	0.842	9.351%
5.45 PM	0.29	0.3114	7.379%
6.15 PM	0.08	0.11	37.5%
6.30 PM	0.025	0.026	4.00%
6.45 PM	0.000	0.000	0.000%

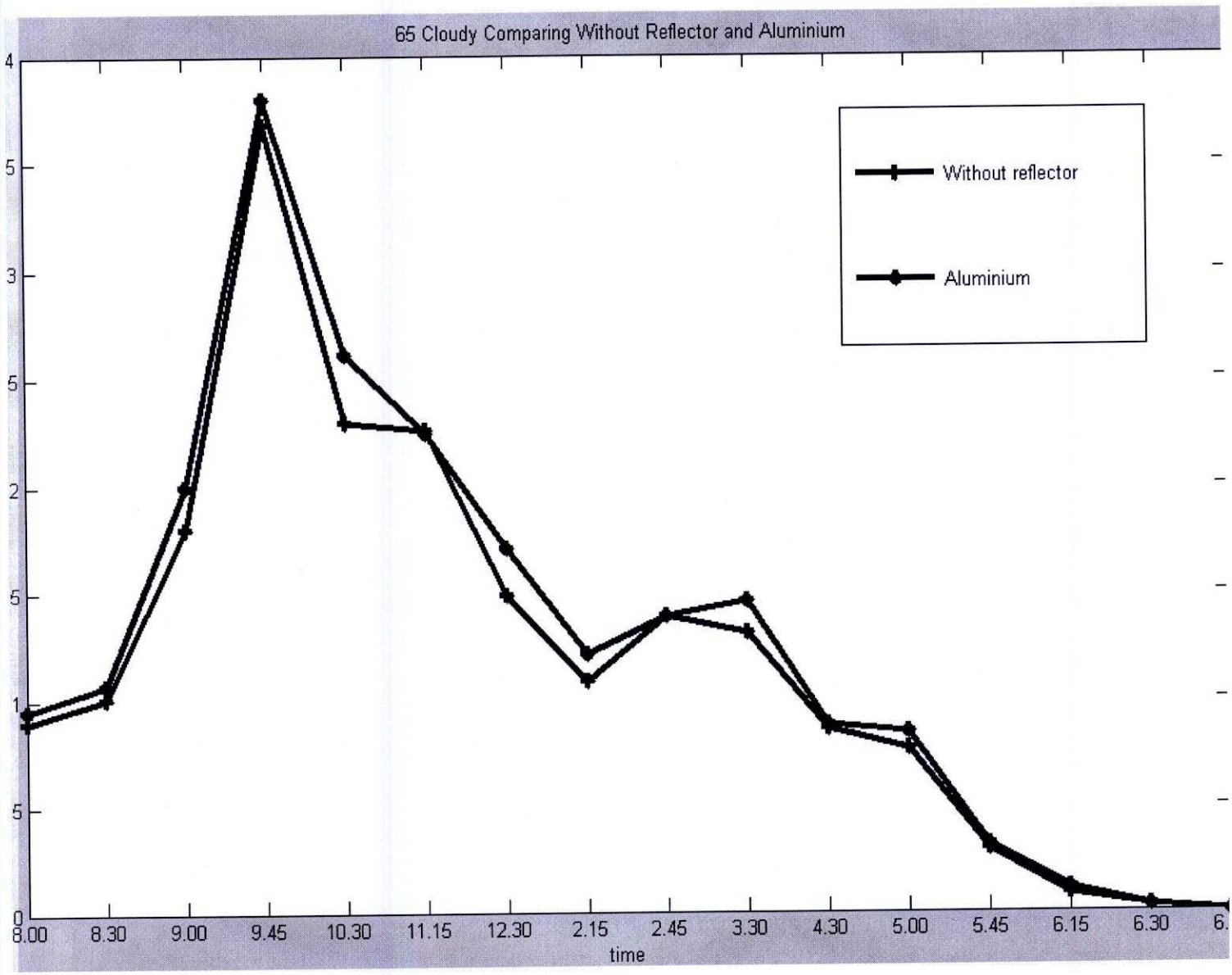

Fig 5.12: Comparing Solar panel and Aluminum reflector at 65° (Cloudy)

5.5.2: Comparing 4 types of Reflector:

Date: 12-11-2010
Angle- 65
Weather: Sunny
Table 5.13 : Power Output comparison of all Reflectors at 65° (Sunny)

Time	Power (watt) without Reflector	Power (watt) with Aluminium Reflector	Power output	Power (watt) with White Foam Reflector	Power output	Power (watt) with Stainless Steel Reflector	Power output	Power (watt) with Standard Reflector	Power output
8.30	0.2564	0.2739	6.825	0.2742	6.9423	0.2739	6.825	0.2565	0.0390
9:00	0.3285	0.3468	5.5708	0.3648	11.05	0.3466	5.509	0.3646	10.989
10:00	2.7133	2.7618	1.7875	2.7603	1.7322	2.7588	1.6769	2.7390	0.9472
11.00	3.6009	3.6353	0.9553	3.6046	0.103	3.6353	0.9553	3.6297	0.7998
12:00	4.1934	4.1955	0.0501	4.1955	0.0501	4.1694	-0.5723	4.2259	0.7750
01:00	4.2522	4.2565	0.101	4.2522	0.000	4.2785	0.6185	4.2217	0.7173
02:00	3.5277	3.5526	0.706	3.6260	2.7865	3.6046	2.1799	3.6279	2.8404
02:30	3.2832	3.3372	1.645	3.3337	1.5381	3.3093	0.795	3.2849	0.0518
03:00	1.3623	1.3631	0.059	1.4052	3.1491	1.3853	1.6883	1.3631	0.0587
03:30	0.6553	0.6926	5.6920	0.6741	2.8689	0.6737	2.8079	0.6556	0.0458
04:00	0.1225	0.1384	12.98	0.1226	0.0816	0.1384	12.98	0.1227	0.1633
05:00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

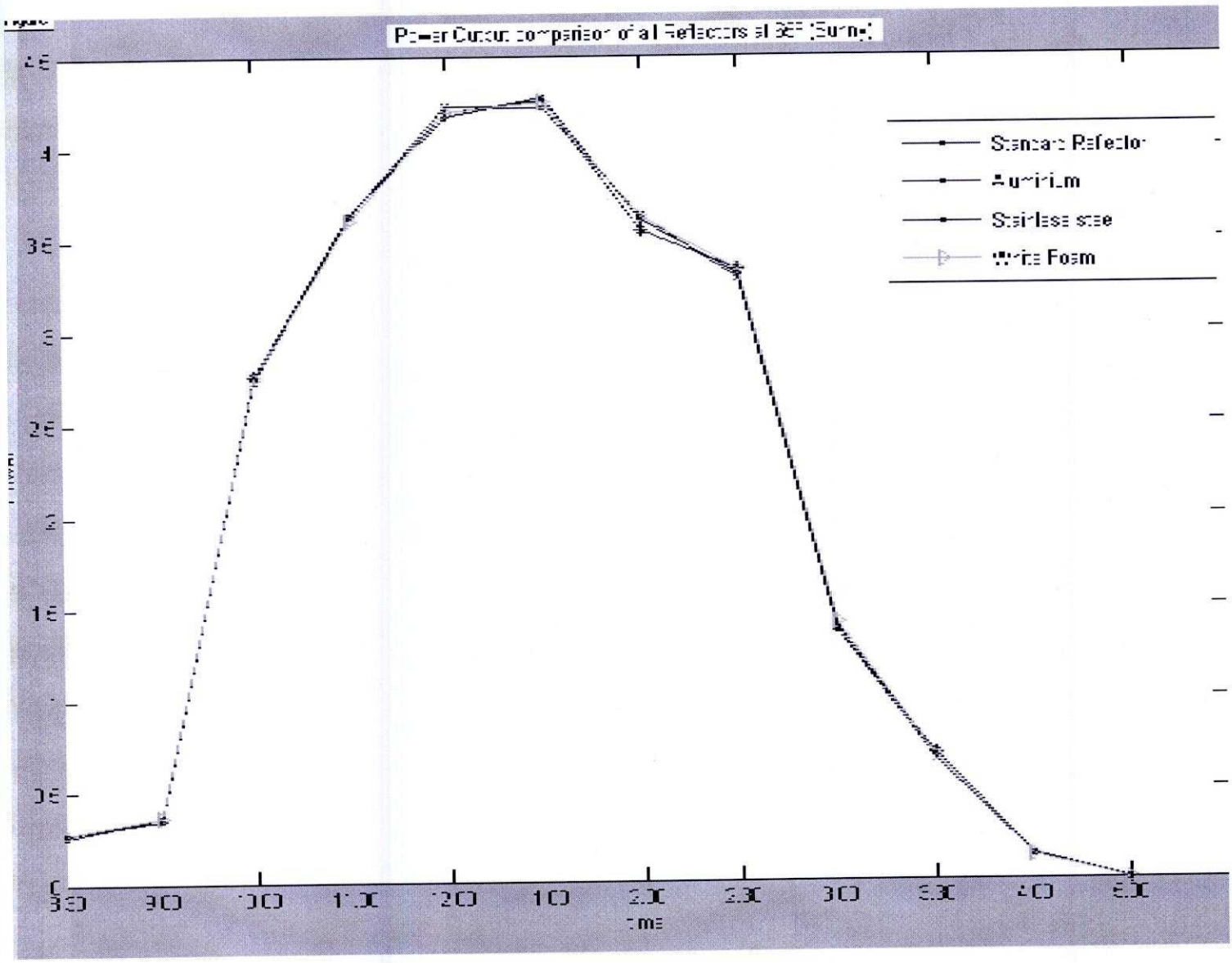

Fig 5.13: Output power comparison of all Reflectors at 65° (Sunny)

Date: 12-11-2010
Angle- 65
Weather: Sunny
Table 5.14 : Power Output comparison of all Reflectors at 65° (Cloudy)

Time	Power, P without Reflector	Power, P Aluminum	Power output(%)	Power, P Stainless steel	Power output (%)	Power, P StandardRef lcector	Power output(%)	Power, P foam	Power output(%)
8:00	2.294	2.451	6.844	1.52	-33.740	2.477	7.977	1.559	-32.040
8:30	2.611	2.48	-5.017	1.915	-26.65	2.865	9.728	2.536	2.872
9:30	1.324	1.562	17.976	0.799	-39.653	1.512	14.199	1.046	-20.997
10:30	2.488	1.728	-30.547	1.71	-31.270	1.703	-31.55	2.291	-7.944
11.30	1.444	1.584	9.695	1.464	1.385	1.683	16.551	1.507	4.363
12:30	0.712	0.728	2.247	0.67	-5.899	0.747	4.915	0.746	4.775
01:30	1.152	1.462	26.909	1.34	16.319	1.522	32.118	1.559	35.329
02:30	1.169	1.284	9.837	1.188	1.625	1.284	9.837	1.247	6.672
03:30	0.919	0.972	5.767	0.914	-0.544	0.955	3.917	0.915	-0.435
04:30	0.652	0.713	9.356	0.724	11.043	0.878	34.663	0.751	15.184
05:00	0.162	0.163	0.617	0.164	1.235	0.164	1.235	0.164	1.235
05:30	0.016	0.016	0.00	0.016	0.00	0.016	0.00	0.016	0.00

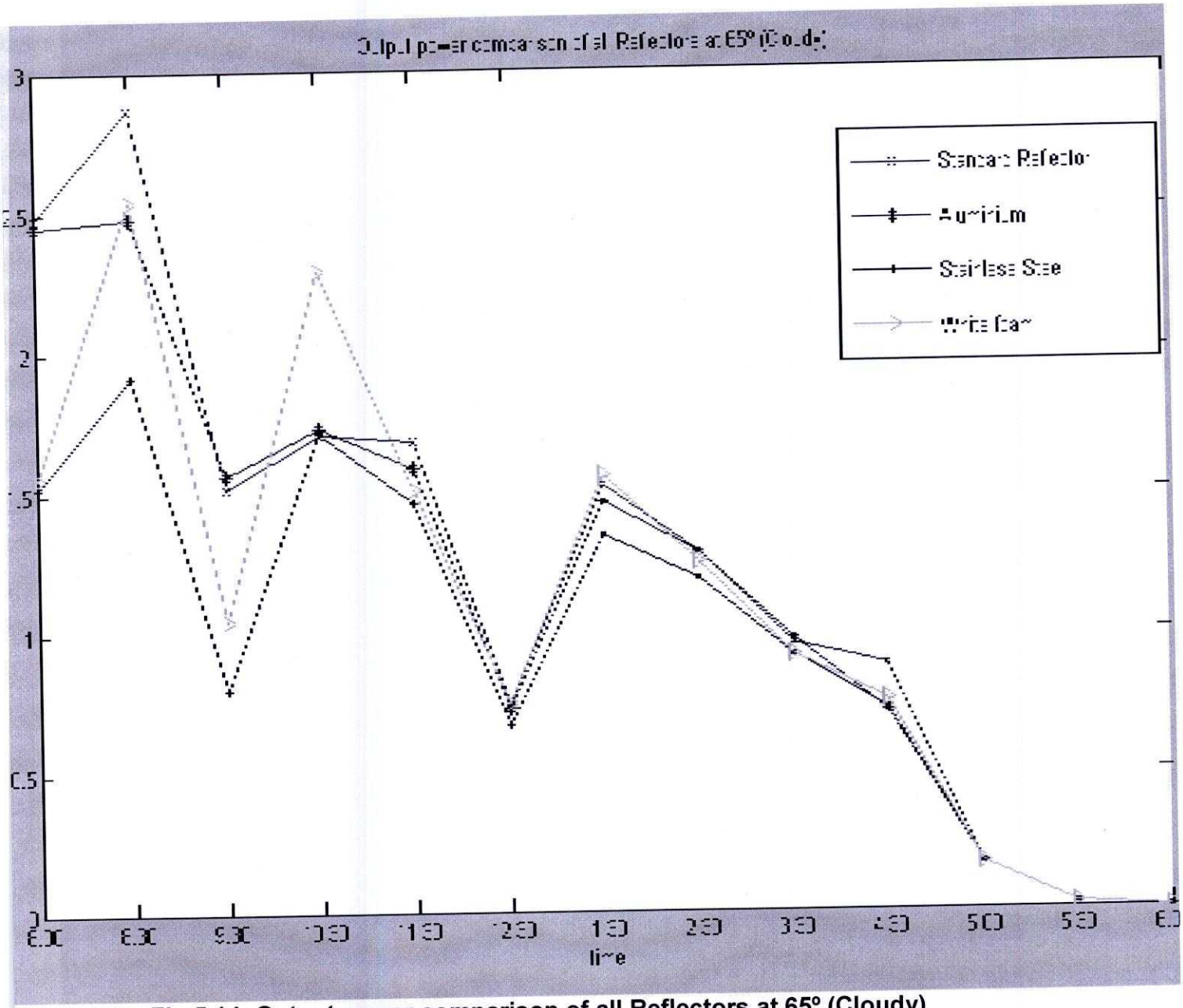

Fig 5.14: Output power comparison of all Reflectors at 65° (Cloudy)

5.6 Comparison between **45°, 55° and 65° angle**

Table: Output Power Comparison Table

Reflector Panels	Angle	Maximum and Minimum Power Output				Average Power Output Increase Rate	
		Sunny		Cloudy		Sunny	Cloudy
		Pmin	Pmax	Pmin	Pmax		
White foam	45	0.011	6.179	0.00	2.098	3.39%	2.93%
	55	0.00	5.398	0.00	0.369	11.42%	3.92%
	65	0.00	4.252	0.016	2.536	2.53%	3.39%
Aluminum	45	0.010	6.138	0.000	2.122	4.55%	3.74%
	55	0.000	5.002	0.000	0.388	7.07%	1.57%
	65	0.000	4.257	0.016	2.480	3.03%	4.47%
Stainless Steel	45	0.010	6.16	0.00	2.123	1.06%	3.83%
	55	0.00	5.368	0.00	0.388	7.58%	3.92%
	65	0.00	4.279	0.016	1.915	2.53%	8.63%
Standard Reflector	45	0.010	6.157	0.00	2.120	0.25%	2.78%
	55	0.00	5.002	0.00	0.388	8.97%	1.93%
	65	0.00	4.226	0.00	2.865	1.45%	0.75%

Power analysis:

The performances of our proposed system have been tested using the data we were achieved during our observation through out the day. After using the reflector, the result indicates that we get higher power output than without reflectors. This system does not provide a constant output. The output voltages for the system were relatively the same throughout and output current varied depending on the amount and intensity of light fall into the solar panel. The reflector position of angle **45°, 55°, and 65°** produce higher power reading. Using two reflectors provide sufficient and efficient output from a solar cell. By adding more reflectors to the system will be more expensive and complex. From the graph we can see at cloudy weather condition the effect of the reflector on to the panel not much significant among them, we can see from the graph that, we get better output at **45°** and **55°**. But at **65°**, Power output is much lower than rest of the angle position. Because, after 12:30pm the shade of the reflector fall into the panel and at the evening, the panel fully covered by the shade. For that, the intensity of light decrease which create less output.

Conclusion:

In this paper, we have considered and investigate the prospect of using reflector with a solar panel. By implementing reflector with the panel, the rated output of a solar panel can be increased. The output can be increased around 40% by using this method. The aluminum finish reflector improved solar cell output than all other reflector. This is simple but effective and beneficial to the energy production of a solar energy system.

For ordinary household we can implement out method to produce extra power, which can be save our electricity and create a clean energy source. This solar energy system will highlight savings both average powers produced and cost per kilowatt hour.

6. Reference:

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6. 1st International Conference on the Developments in Renewable Energy Technology (ICDET -2009) ; **Concentrating Solar Power (CSP) and Its Prospect in Bangladesh;** Nafisa Noor, Sadid Muneer

Appendix "A"
All data of 45°
Sunny Weather (summer)

DATE-19.07.10
Day-Monday
Weather – Sunny
Without Reflector
Table: 1.1

Time	Voc	Isc	Power, P	Weather
8.15	14.29	0.013	0.186	Sunny
9.00	14.45	0.019	0.275	Sunny
10.00	16.66	0.019	0.317	Sunny
10.45	18.89	0.311	5.875	Sunny
11.30	17.83	0.27	4.814	Sunny
11.45	17.50	0.27	4.725	Sunny
12.30	17.97	0.321	5.76837	Sunny
1.15	18.82	0.375	7.0575	Sunny
2.00	18.37	0.318	5.84166	Sunny
2.45	18.80	0.214	4.03	Sunny
3.30	17.39	0.24	4.17	Sunny
4.30	18.90	0.232	4.385	Sunny
5.15	17.78	0.025	0.445	Sunny
5.45	16.40	.013	.2132	Sunny
6.00	15.38	0.006	0.0923	Sunny
6.30	11.05	0.001	0.011	Sunny
7.00	10.97	0.00	0.00	Sunny

Maximum Power, Pmax=7.058 W

Maximum Short Circuit Current, Isc=0.375 A

Maximum Open Circuit Voltage, Voc=18.90 V

DATE-19.07.10
Day-Monday
Angle-45 degree
Reflector Type: Aluminum
Reflector position: North-South
Table: 1.2

Time	Voc	Isc	Power, P	Weather
8.00	14.70	0.02	0.294	Sunny
9.00	14.45	0.019	0.275	Sunny
10.00	16.79	0.026	0.437	Sunny
10.45	18.90	0.323	6.105	Sunny
11.30	17.80	0.28	4.984	Sunny
11.45	17.71	0.333	5.897	Sunny
12.30	17.98	0.321	5.772	Sunny
1.15	18.96	0.355	6.7308	Sunny
2.00	18.98	0.377	7.155	Sunny
2.45	18.23	0.332	6.052	Sunny
3.30	18.32	0.332	6.082	Sunny
4.30	18.41	0.031	5.71	Sunny
5.15	17.65	0.024	0.424	Sunny
5.45	16.38	0.14	0.229	Sunny
6.00	13.02	0.002	0.124	Sunny
6.30	11.02	.001	0.011	Sunny
7.00	6.2	0.00	0.00	Sunny

Maximum Power, Pmax=7.155 W
Maximum Short Circuit Current, Isc=0.377 A
Maximum Open Circuit Voltage, Voc=18.98 V

DATE-19.07.10
Day-Monday
Angle: 45 degree
Reflector Type: Stainless Steel
Reflector position: North-South

Table: 1.3

Time	Voc	Isc	Power, P	Weather
8.15	13.45	0.010	0..257	Sunny
9.00	14.77	0.030	0.443	Sunny
10.00	14.22	0.020	0.284	Sunny
10.45	18.96	0.322	6.105	Sunny
11.30	17.77	0.029	5.153	Sunny
11.45	17.22	0.034	5.855	Sunny
12.30	17.98	0.299	5.376	Sunny
1.15	18.87	0.342	6.454	Sunny
2.00	18.72	0.363	6.795	Sunny
2.45	18.11	0.297	5.379	Sunny
3.30	18.62	0.329	6.126	Sunny
4.30	14.96	0.008	5.34	Sunny
5.15	14.01	0.004	0.424	Sunny
5.45	16.38	0.011	0.18	Sunny
6.00	12.47	0.001	0.092	Sunny
6.30	10.97	0.000	0.011	Sunny
7.00	6.23	0.00	0.00	Sunny

Maximum Power, Pmax=6.795 W
Maximum Short Circuit Current, Isc=0.363A
Maximum Open Circuit Voltage, Voc=18.96 V

DATE-19.07.10
Day-Monday
Angle: 45 degree
Reflector Type: White Foam
Reflector position: North-South

Table: 1.4

Time	Voc	Isc	Power, P	Weather
8.00	14.72	0.017	0..251	Sunny
9.00	14.49	0.025	0.36225	Sunny
10.00	14.78	0.021	0.31038	Sunny
10.45	18.92	0.319	6.03548	Sunny
11.30	17.79	0.29	5.1591	Sunny
11.45	17.34	0.32	5.5488	Sunny
12.30	17.92	0.320	5.7344	Sunny
1.15	18.97	0.362	6.86714	Sunny
2.00	18.70	0.366	6.8442	Sunny
2.45	18.11	0.300	5.433	Sunny
3.30	17.02	0.210	3.574	Sunny
4.30	18.96	0.30	0.1507	Sunny
5.15	17.32	0.022	0.04206	Sunny
5.45	16.42	0.013	0.213	Sunny
6.00	15.39	0.003	0.123	Sunny
6.30	11.03	0.000	0.011	Sunny
7.00	6.23	0.00	0.00	Sunny

Maximum Power, Pmax=6.86 W
Maximum Short Circuit Current, Isc=0.366 A
Maximum Open Circuit Voltage, Voc=18.96 V

DATE-9.07.10
Day- Friday
Angle: 45 degree
Weather: Sunny

Table: 1.5 –Efficiency increase rate of different Reflector:

Time	Without Reflector, Power, P	Aluminum, Power, P	% increase using Aluminum	Stainless Steel. Power, P	% increase using Stainless Steel	White Foam, Power, P	% Increase Using White Foam
8.00	0.286	0.294	2.79	0.287	0.34	0.291	1.74
9.00	0.275	0.275	0.00	0.443	24.73	0.36225	31.75
10.00	0.317	0.437	37.85	0.284	-10.28	0.31038	-2.11
10.45	5.875	6.105	3.91	6.105	3.917	6.03548	2.73
11.30	4.814	4.984	3.62	5.153	7.131	5.1591	7.25
11.45	4.725	5.897	24.67	5.855	23.78	5.5488	17.31
12.30	5.76837	5.772	0.069	5.376	-6.8	5.7344	-0.598
1.15	7.0575	6.7308	-4.63	6.454	-8.56	6.86714	-2.71
2.00	5.84166	7.155	22.48	6.795	16.31	6.8442	17.15
3.30	4.17	6.082	45.85	6.126	46.91	3.574	-14.29
4.30	4.385	5.71	29.99	5.34	21.78	0.1507	29.72
5.15	0.445	0.424	-4.72	0.424	-4.72	0.04206	-14.3
5.45	.2132	0.229	7.512	0.18	-15.49	0.213	0.00
6.00	0.0923	0.124	34.35	0.092	0.00	0.123	33.26
6.30	0.011	0.011	-0.45	0.011	-0.4	0.011	0.00
7.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Maximum Efficiency Increase:

- Aluminum: 45.85%
- Stainless steel: 46.91%
- White foam: 34.94%

Appendix "B"
All data of 45°
Cloudy Weather (summer)

DATE-16.07.10
Day-Friday
Without Reflector

Table: 2.1

Time	Voc	Isc	Power, P	Weather
8.30 AM	14.29	0.013	0.1858	Cloudy
9.15 AM	16.11	0.018	0.2899	Cloudy
10.00 AM	16.66	0.019	0.3165	Cloudy
11.15 AM	17.85	0.029	0.5177	Cloudy
12.00 PM	17.02	0.016	0.2723	Cloudy
1.00 PM	19.65	0.049	0.9629	Cloudy
2.00 PM	18.92	0.0481	0.9101	Cloudy
2.45 PM	18.89	0.0430	0.8123	Cloudy
3.30 PM	17.39	0.024	0.4174	Cloudy
4.15 PM	18.90	0.0232	0.4385	Cloudy
5.00 PM	17.78	0.025	0.4445	Cloudy
5.45 PM	16.40	0.013	0.2132	Cloudy
6.15 PM	15.38	0.006	0.0923	Cloudy
6.45 PM	11.05	0.001	0.0111	Cloudy
7.00 PM	6.23	0.000	0.000	Cloudy

Maximum Power, Pmax= 0.9629 W
Maximum Open circuit Voltage, Voc= 19.65 V
Maximum Short circuit Current, Isc = 0.049 Amp
DATE-16.07.10

Day-Friday
Angle-45
Reflector type- Aluminium
Reflector position-North-South

Table: 2.2

Time	Voc	Isc	Power, P	Weather
8.30 AM	14.70	0.020	0.294	Cloudy
9.15 AM	16.13	0.018	0.2903	Cloudy
10.00 AM	16.79	0.026	0.4365	Cloudy
11.15 AM	17.86	0.036	0.6429	Cloudy
12.00 PM	17.13	0.018	0.3083	Cloudy
1.00 PM	19.28	0.0739	1.4248	Cloudy
2.00 PM	18.9	0.079	1.5011	Cloudy
2.45 PM	18.88	0.0667	1.201	Cloudy
3.30 PM	18.32	0.0332	0.6082	Cloudy
4.15 PM	18.41	0.031	0.5707	Cloudy
5.00 PM	17.65	0.024	0.4236	Cloudy
5.45 PM	16.38	0.014	0.2293	Cloudy
6.15 PM	15.45	0.008	0.1236	Cloudy
6.45 PM	11.02	0.001	0.0110	Cloudy
7.00 PM	6.23	0.000	0.000	Cloudy

Maximum Power, Pmax= 1.5011W
Maximum Open circuit Voltage, Voc= 19.28V
Maximum Short circuit Current, Isc = 0.079Amp

DATE-16.07.10
Day- Friday
Angle-45
Reflector Type-Stainless Steel
Reflector position-North-South
Table: 2.3

Time	Voc	Isc	Power, P	Weather
8.30 AM	14.89	0.024	0.3574	Cloudy
9.15 AM	16.38	0.016	0.2621	Cloudy
10.00 AM	16.33	0.011	0.1797	Cloudy
11.15 AM	18.30	0.020	0.366	Cloudy
12.00 PM	17.30	0.020	0.346	Cloudy
1.00 PM	19.34	0.0783	1.515	Cloudy
2.00 PM	19.78	0.0754	1.492	Cloudy
2.45 PM	18.90	0.063	1.191	Cloudy
3.30 PM	18.62	0.0329	0.6126	Cloudy
4.15 PM	18.43	0.029	0.5345	Cloudy
5.00 PM	17.68	0.024	0.4243	Cloudy
5.45 PM	16.38	0.011	0.1802	Cloudy
6.15 PM	15.32	0.006	0.0919	Cloudy
6.45 PM	11.02	0.001	0.0110	Cloudy
7.00 PM	6.23	0.000	0.000	Cloudy

Maximum Power, Pmax=1.515W
Maximum Open circuit Voltage, Voc=19.78 V
Maximum Short circuit Current, Isc =0.0783Amp

DATE-16.07.10
Day- Friday
Angle-45
Reflector Type-White Foam
Reflector position-North-South
Table: 2.4

Time	Voc	Isc	Power, P	Weather
8.30 AM	14.72	0.020	0.2944	Cloudy
9.15 AM	16.45	0.017	0.2797	Cloudy
10.00 AM	16.02	0.013	0.2083	Cloudy
11.15 AM	18.42	0.031	0.5710	Cloudy
12.00 PM	17.34	0.021	0.3641	Cloudy
1.00 PM	18.20	0.081	1.4742	Cloudy
2.00 PM	19.69	0.072	1.42	Cloudy
2.45 PM	18.91	0.065	1.237	Cloudy
3.30 PM	17.02	0.041	0.6978	Cloudy
4.15 PM	18.96	0.030	0.5688	Cloudy
5.00 PM	17.32	0.022	0.3810	Cloudy
5.45 PM	16.42	0.013	0.2135	Cloudy
6.15 PM	15.39	0.008	0.1231	Cloudy
6.45 PM	11.03	0.001	0.0110	Cloudy
7.00 PM	6.23	0.000	0.000	Cloudy

Maximum Power, Pmax= 1.4742W
Maximum Open circuit Voltage, Voc=19.69 V
Maximum Short circuit Current, Isc = 0.081 Amp

DATE-16.07.10
Day-Friday
Angle – 45 degree
Weather - Cloudy
Power comparison of different Reflector
Table: 2.5

Time	Without Reflector, Power, P	Aluminium, Power, P	% increase using Aluminium	Stainless Steel. Power, P	% increase using Stainless Steel	White Foam, Power, P	% Increase Using White Foam
8.30 AM	0.2858	0.294	2.86%	0.3574	25.05%	0.2944	3.009%
9.15 AM	0.2899	0.2903	0.138%	0.2621	-9.59%	0.2797	-3.52%
10.00 AM	0.3165	0.4365	37.91%	0.1797	-43.22%	0.2083	-34.19%
11.15 AM	0.5177	0.6429	24.18%	0.366	-29.3%	0.5710	10.29%
12.00 PM	0.2723	0.3083	13.22%	0.346	27.07%	0.3641	33.71%
1.00 PM	0.9629	1.4248	47.97%	1.515	57.29%	1.4742	43.10%
2.45 PM	0.8123	1.201	47.85%	1.191	46.62%	1.237	42.28%
4.15 PM	0.4385	0.5707	30.15%	0.5345	21.89%	0.5688	29.71%
5.00 PM	0.4445	0.4236	-4.701%	0.4243	-4.54%	0.3810	-14.29%
5.45 PM	0.2132	0.2293	7.55%	0.1802	-15.48%	0.2135	0.141%
6.15 PM	0.0923	0.1236	33.91%	0.0919	-0.43%	0.1231	33.37%
6.45 PM	0.0111	0.0110	-0.901%	0.0110	-0.901%	0.0110	-0.901%
7.00 PM	0.000	0.000	0.00%	0.000	0.00%	0.000	0.00%

Maximum Power, Pmax = 1.515 W
Maximum Efficiency Increase=43.10% (White Foam)
Maximum Efficiency Increase=47.97% (Aluminium)
Maximum Efficiency Increase=46.62% (Stainless Steel)

Appendix "C"
All data of 45°
Sunny Weather (winter)

DATE-12.10.10
Day-Monday
Angle-45
With reflector-Without Reflector
Reflector position-North-South

Time	Voc	Isc	Power, P	Weather
8:00	14.79	0.012	0.1775	sunny
9:00	15.23	0.018	0.274	sunny
10:00	17.79	0.082	1.4588	sunny
10:30	18.56	0.31	5.7536	sunny
11.00	18.37	0.318	5.8417	sunny
12:00	18.90	0.282	5.3298	sunny
12.30	19.03	0.23	4.3769	sunny
01:00	19.27	0.321	6.1857	sunny
02:00	19.14	0.294	5.6272	sunny
03:00	18.76	0.194	3.7639	sunny
03:30	17.88	0.053	0.9476	sunny
04:00	17.22	0.019	0.3272	sunny
04:30	15.99	0.009	0.1439	sunny
05:00	13.52	0.004	0.0541	sunny
05:30	10.33	0.001	0.0103	sunny

Maximum Open Circuit Voltage, Voc = 19.27
Maximum Short Circuit Current, Isc = 0.321
Maxium Power, Pmax = 6.1857

DATE-12.10.10
Day-Sunday
Angle-45
With reflector-Aluminium
Reflector position-North-South

Time	Voc	Isc	Power, P	Weather
8:00	14.82	0.013	0.1927	sunny
9:00	15.38	0.020	0.3076	sunny
10:00	17.69	0.078	1.379	sunny
10:30	18.51	0.29	5.3679	sunny
11.00	18.42	0.320	5.8944	sunny
12:00	18.97	0.286	5.4254	sunny
12.30	19.11	0.23	4.3953	sunny
01:00	19.24	0.319	6.1376	sunny
02:00	19.15	0.295	5.6493	sunny
03:00	18.79	0.196	3.6828	sunny
03:30	17.95	0.055	0.9873	sunny
04:00	17.28	0.022	0.3802	sunny
04:30	16.02	0.009	0.1442	sunny
05:00	13.54	0.005	0.0677	sunny
05:30	10.35	0.001	0.010	sunny

Maximum Open Circuit Voltage, Voc = 19.24
Maximum Short Circuit Current, Isc = 0.319
Maxium Power, Pmax = 6.1376

DATE-12.10.10
Day-Monday
Angle-55
With reflector-Stainless Steel
Reflector position-North-South

Time	Voc	Isc	Power, P	Weather
8:00	14.81	0.013	0.1925	sunny
9:00	15.25	0.018	0.2745	sunny
10:00	17.81	0.083	1.4782	sunny
10:30	18.61	0.320	5.955	sunny
11.00	18.37	0.318	5.8416	sunny
12:00	18.99	0.290	5.5071	sunny
12.30	19.07	0.23	4.3861	sunny
01:00	19.25	0.32	6.16	sunny
02:00	19.09	0.293	5.593	sunny
03:00	18.77	0.194	3.6414	sunny
03:30	17.91	0.054	0.9671	sunny
04:00	17.25	0.020	0.343	sunny
04:30	16.01	0.009	0.144	sunny
05:00	13.49	0.004	0.054	sunny
05:30	10.34	0.001	0.010	sunny

Maximum Open Circuit Voltage, Voc = 19.25
Maximum Short Circuit Current, Isc = 0.32
Maxium Power, Pmax = 6.16

DATE-12.10.10
Day-Sunday
Angle-45
With reflector-Foam Core
Reflector position-North-South

Time	Voc	Isc	Power, P	Weather
8:00	14.84	0.014	0.2078	sunny
9:00	15.30	0.019	0.2907	sunny
10:00	17.69	0.078	1.379	sunny
10:30	18.50	0.27	4.995	sunny
11.00	18.43	0.320	5.8976	sunny
12:00	18.91	0.27	5.3137	sunny
12.30	18.99	0.20	3.798	sunny
01:00	19.25	0.321	6.179	sunny
02:00	19.15	0.25	5.649	sunny
03:00	18.81	0.197	3.7056	sunny
03:30	17.96	0.056	1.006	sunny
04:00	17.25	0.022	0.3795	sunny
04:30	16.02	0.009	0.144	sunny
05:00	13.55	0.005	0.0677	sunny
05:30	10.35	0.001	0.0104	sunny

Maximum Open Circuit Voltage, Voc = 19.25
Maximum Short Circuit Current, Isc = 0.321
Maxium Power, Pmax = 6.179

DATE-12.10.10
Day-Monday
Angle-45
With reflector- Standard Reflector
Reflector position-North-South

Time	Voc	Isc	Power, P	Weather
8:00	14.76	0.011	0.1624	sunny
9:00	15.38	0.020	0.3016	sunny
10:00	17.75	0.080	1.42	sunny
10:30	18.58	0.310	5.7528	sunny
11.00	18.39	0.319	5.86441	sunny
12:00	18.97	0.286	5.4204	sunny
12.30	19.13	0.23	4.3999	sunny
01:00	19.24	0.320	6.157	sunny
02:00	19.06	0.291	5.5465	sunny
03:00	18.79	0.196	3.6828	sunny
03:30	17.92	0.054	0.9647	sunny
04:00	17.29	0.020	0.346	sunny
04:30	16.00	0.009	0.144	sunny
05:00	13.52	0.004	0.054	sunny
05:30	10.34	0.001	0.0103	sunny

Maximum Open Circuit Voltage, Voc = 19.24
Maximum Short Circuit Current, Isc = 0.320
Maxium Power, Pmax = 6.157

Table: power output increase

Time	Power (watt) without Reflector	Power (watt) with Aluminium Reflector	Power output(%)	Power (watt) with White Foam Reflector	Power output	Power (watt) with Stainless Steel Reflector	Power output	Power (watt) with Standard Reflector	Power output
8.00	0.18	0.19	5.55	0.16	-11.11	0.19	5.56	0.16	-11.11
9:00	0.27	0.31	14.81	0.31	14.81	0.27	0.00	0.30	11.11
10:00	1.46	1.38	-5.48	1.42	-2.74	1.48	1.37	1.42	-2.74
10:30	5.75	5.37	-6.61	5.76	0.17	5.96	3.65	5.75	0.00
11.00	5.84	5.89	0.86	5.87	0.51	5.84	0.00	5.86	0.34
12:00	5.33	5.43	1.88	5.43	1.88	5.51	3.38	5.42	1.69
12:30	4.38	4.40	0.46	4.40	0.46	4.39	0.23	4.40	0.46
01:00	6.19	6.14	-0.81	6.16	0.48	6.16	0.48	6.16	0.48
02:00	5.63	5.65	0.36	5.65	0.36	5.59	-0.71	5.55	-1.42
03:00	3.76	3.68	-2.13	3.68	-2.13	3.64	-3.19	3.68	-2.13
03:30	0.95	0.99	4.21	0.97	2.11	0.97	2.11	0.96	1.05
04:00	0.33	0.38	15.15	0.35	6.06	0.34	3.03	0.35	6.06
04.30	0.14	0.14	0.00	0.14	0.00	0.14	0.00	0.14	0.00
05.00	0.05	0.07	40.00	0.07	40.00	0.05	0.00	0.05	0.00
05:30	0.01	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00

Appendix "D"
All data of 45°
Cloudy Weather (winter)

DATE- 31-10-2010
Day- Sunday
Angle-45
With reflector-Without Reflector
Reflector position-North-South

Time	Voc	Isc	Power, P	Weather
8:30	16.96	0.014	0.2374	cloudy
9:00	16.36	0.008	0.1309	cloudy
10:00	17.25	0.018	0.3105	cloudy
11.00	16.79	0.013	0.2183	cloudy
12.00	17.53	0.022	0.3857	cloudy
1:00	18.58	0.113	2.0995	cloudy
1.30	18.41	0.108	1.9883	cloudy
2:30	18.36	0.071	1.3036	cloudy
3:00	15.42	0.010	0.1542	cloudy
4:30	13.32	0.004	0.0533	cloudy
5:00	10.23	0.00	0.000	cloudy

Maximum Open Circuit Voltage, Voc = 18.58
Maximum Short Circuit Current, Isc = 0.113
Maxium Power, Pmax = 2.0995

DATE- 31-10-2010
Day- Sunday
Angle-45
With reflector-Aluminum
Reflector position-North-South

Time	Voc	Isc	Power, P	Weather
8:30	16.98	0.014	0.2377	cloudy
9:00	16.38	0.009	0.1472	cloudy
10:00	17.25	0.018	0.33	cloudy
11.00	16.89	0.014	0.2365	cloudy
12.00	17.59	0.023	0.4046	cloudy
1:00	18.61	0.114	2.1216	cloudy
1.30	18.43	0.109	2.009	cloudy
2:30	18.41	0.074	1.6323	cloudy
3:00	15.39	0.009	0.1385	cloudy
4:30	13.38	0.005	0.0669	cloudy
5:00	10.21	0.00	0.000	cloudy

Maximum Open Circuit Voltage, Voc = 18.61
Maximum Short Circuit Current, Isc = 0.114
Maxium Power, Pmax = 2.1216

DATE- 31-10-2010
Day- Sunday
Angle-45
With reflector-Stainless Steel
Reflector position-North-South

Time	Voc	Isc	Power, P	Weather
8:30	17.08	0.015	0.2562	cloudy
9:00	16.37	0.009	0.1473	cloudy
10:00	17.29	0.019	0.3285	cloudy
11.00	16.91	0.015	0.2537	cloudy
12.00	17.61	0.024	0.4226	cloudy
1:00	18.62	0.114	2.1227	cloudy
1.30	18.45	0.109	2.0111	cloudy
2:30	18.40	0.074	1.3616	cloudy
3:00	15.41	0.009	0.1387	cloudy
4:30	13.32	0.004	0.0533	cloudy
5:00	10.28	0.00	0.000	cloudy

Maximum Open Circuit Voltage, Voc = 18.62
Maximum Short Circuit Current, Isc = 0.114
Maxium Power, Pmax = 2.1227

DATE- 31-10-2010
Day- Sunday
Angle-45
With reflector- Foam Core
Reflector position-North-South

Time	Voc	Isc	Power, P	Weather
8:30	17.12	0.015	0.2568	cloudy
9:00	16.33	0.008	0.1306	cloudy
10:00	17.38	0.020	0.3476	cloudy
11.00	16.82	0.013	0.2187	cloudy
12.00	17.62	0.024	0.4229	cloudy
1:00	18.57	0.113	2.0984	cloudy
1.30	18.45	0.110	2.0295	cloudy
2:30	18.44	0.075	1.383	cloudy
3:00	15.43	0.010	0.1543	cloudy
4:30	13.35	0.004	0.0534	cloudy
5:00	10.27	0.00	0.000	cloudy

Maximum Open Circuit Voltage, Voc = 18.57
Maximum Short Circuit Current, Isc = 0.113
Maxium Power, Pmax = 2.0984

DATE- 31-10-2010
Day- Sunday
Angle-45
With reflector- Standard Reflector
Reflector position-North-South

Time	Voc	Isc	Power, P	Weather
8:30	17.08	0.015	0.2562	cloudy
9:00	16.29	0.008	0.1303	cloudy
10:00	17.31	0.019	0.3289	cloudy
11.00	16.88	0.014	0.2363	cloudy
12.00	17.60	0.023	0.4048	cloudy
1:00	18.60	0.114	2.1204	cloudy
1.30	18.44	0.110	2.0284	cloudy
2:30	18.45	0.075	1.3838	cloudy
3:00	15.49	0.010	0.1549	cloudy
4:30	13.36	0.004	0.0534	cloudy
5:00	10.26	0.00	0.000	cloudy

Maximum Open Circuit Voltage, Voc = 18.60
Maximum Short Circuit Current, Isc = 0.114
Maxium Power, Pmax = 2.1204

Angle- 45
Weather: cloudy
Date: 31-10-2010
Table: Power Output Increase Rate

Time	Power (watt) without Reflector	Power (watt) with Aluminium Reflector	Power output (%)	Power (watt) with White Foam Reflector	Power output (%)	Power (watt) with Stainless Steel Reflector	Power output (%)	Power (watt) with Standard Reflector	Power output (%)
8.30	0.2374	0.2377	0.1264	0.2568	8..1786	0.2562	7.919	0.2562	7.919
9:00	0.139	0.1472	5.899	0.1306	-6.043	0.1473	5.9712	0.1303	-6.259
10:00	0.3105	0.3105	0.000	0.3476	11.948	0.3285	5.7971	0.3289	5.925
11.00	0.2183	0.2365	8.337	0.2187	0.183	0.2537	16.216	0.2363	8.246
12:00	0.3857	0.4046	4.900	0.4229	9.645	0.4226	9.567	0.4048	4.952
01:00	2.0995	2.1216	1.0526	2.0984	-0.0524	2.1227	1.105	2.1204	1.000
01:30	1.9883	2.009	1.0411	2.0295	2.0721	2.0111	1.147	2.0284	2.0168
02:30	1.3036	1.3623	4.503	1.383	6.0908	1.3616	4.449	1.3838	6.152
03:30	0.1542	0.1385	-10.18	0.1543	0.065	0.1387	-10.052	0.1549	0.454
04:30	0.0533	0.0669	25.51	0.0534	0.1876	0.0533	0.000	0.0534	0.1876
05.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Appendix "E"
All data of 55°
Sunny Weather (summer)

DATE-9.07.10
Angle-55
Without reflector

Table: 3.1

Time	Voc	Isc	Power, P	Weather condition
8.00	19.20	0.19	3.648	Sunny
8.30	19.80	0.231	4.5738	Sunny
9.00	19.40	0.270	5.238	Sunny
9.30	19.31	0.250	4.8275	Sunny
10.30	19.50	0.308	6.006	Sunny
11.00	19.30	0.314	6.0602	Sunny
11.30	19.05	0.302	5.7531	Sunny
12.30	18.94	0.329	6.2313	Sunny
1.00	18.48	0.295	5.452	Sunny
2.30	19.50	0.249	4.8555	Sunny
3.00	19.21	0.250	4.8025	Sunny
4.30	18.65	0.103	1.9209	Sunny
5.30	17.7	0.04	0.708	Sunny
6.30	13.10	0.002	0.0262	Sunny
6.40	10.0	0.00	0.00	Sunny

Maximum Open Circuit Voltage, Voc = 19.80 V
Maximum Short Circuit Current, Isc = 0.329 A
Maximum Power, Pmax = 6.2313 watt

DATE-9.07.10
Angle: 55
Reflector Type: Aluminum
Reflector position: North-South

Table: 3.2

Time	Voc	Isc	Power, P	Weather condition
8.00	19.22	0.237	4.555	Sunny
8.30	19.85	0.260	5.161	Sunny
9.00	19.70	0.255	5.0235	Sunny
9.30	19.16	0.284	5.4414	Sunny
10.30	19.05	0.390	7.4295	Sunny
11.00	19.02	0.355	6.7521	Sunny
11.30	19.04	0.417	7.9397	Sunny
12.30	18.79	0.455	8.5495	Sunny
1.00	18.44	0.354	6.5278	Sunny
2.30	19.32	0.266	5.1391	Sunny
3.00	19.04	0.254	4.8362	Sunny
4.30	18.7	0.106	1.9822	Sunny
5.30	17.55	0.09	1.5795	Sunny
6.30	12.18	0.002	0.0244	Sunny
6.40	10.8	0.00	0.00	Sunny

Maximum Open Circuit Voltage, Voc = 19.85 V
Maximum Short Circuit Current, Isc = 0.455A
Maximum Power, Pmax = 8.5495 watt

DATE-9.07.10
Angle: 55
Reflector Type: Stainless steel
Reflector position: North-South

Table: 3.3

Time	Voc	Isc	Power, P	Weather condition
8.00	19.20	0.231	4.4352	Sunny
8.30	19.66	0.246	4.8364	Sunny
9.00	19.67	0.257	5.0552	Sunny
9.30	19.15	0.260	4.979	Sunny
10.30	19.50	0.347	6.7665	Sunny
11.00	19.22	0.328	5.3202	Sunny
11.30	19.04	0.348	6.6259	Sunny
12.30	18.60	0.359	6.6774	Sunny
1.00	18.58	0.313	5.8155	Sunny
2.30	19.49	0.264	5.1454	Sunny
3.00	18.98	0.233	4.4223	Sunny
4.30	18.65	0.104	1.9396	Sunny
5.30	17.5	0.08	1.4	Sunny
6.30	12.59	0.002	0.02518	Sunny
6.40	10.0	0.00	0.00	Sunny

Maximum Open Circuit Voltage, Voc = 19.67 V
Maximum Short Circuit Current, Isc = 0.359 A
Maximum Power, Pmax = 6.7665watt

DATE-9.07.10
Angle: 55
Reflector Type: White Foam
Reflector position: North-South

Table: 3.4

Time	Voc	Isc	Power, P	Weather condition
8.00	19.20	0.233	4.4736	Sunny
8.30	19.66	0.242	4.7577	Sunny
9.00	19.67	0.26	5.1142	Sunny
9.30	19.15	0.265	5.0748	Sunny
10.30	19.50	0.345	6.7275	Sunny
11.00	19.22	0.340	6.5348	Sunny
11.30	19.04	0.352	6.7021	Sunny
12.30	18.60	0.360	6.696	Sunny
1.00	18.58	0.314	5.834	Sunny
2.30	19.49	0.262	5.1064	Sunny
3.00	18.98	0.232	4.4034	Sunny
4.30	18.65	0.116	2.1634	Sunny
5.30	17.5	0.08	1.4	Sunny
6.30	12.59	0.002	0.02518	Sunny
6.40	10.0	0.00	0.00	Sunny

Maximum Open Circuit Voltage, Voc = 19.66 V
Maximum Short Circuit Current, Isc = 0.360 A
Maximum Power, Pmax = 6.7275 watt

DATE-9.07.10
Day-: Friday
Angle: 55
Weather: Sunny

Table: 3.5: Efficiency increase rate of different Reflector:

Without Reflector, Power, P	Aluminum, Power, P	% increase using Aluminum	Stainless Steel. Power, P	% increase using Stainless Steel	White Foam, Power, P	% Increase Using White Foam
3.648	4.555	22.6312	4.4352	21.579	4.4736	24.863
4.5738	5.161	4.0207	4.8364	5.741	4.7577	12.838
5.238	5.0235	-2.3635	5.0552	-3.49	5.1142	-4.095
4.8275	5.4414	5.1227	4.979	3.138	5.0748	12.717
6.006	7.4295	12.013	6.7665	12.662	6.7275	23.701
6.0602	6.7521	7.8314	5.3202	-12.211	6.5348	11.417
5.7531	7.9397	16.495	6.6259	15.171	6.7021	38.007
6.2313	8.5495	7.4575	6.6774	7.159	6.696	37.203
5.452	6.5278	7.006	5.8155	6..6673	5.834	19.732
4.8555	5.1391	5.1673	5.1454	5.9705	5.1064	5.841
4.8025	4.8362	-8.3103	4.4223	-7.917	4.4034	0.702
1.9209	1.9822	12.624	1.9396	0.974	2.1634	3.191
0.708	1.5795	2.189	1.4	2.189	1.4	15.29
0.0262	0.0244	-3.8931	0.02518	-3.8931	0.02518	-6.870
0.00	0.00	0.00	0.00	0.00	0.00	0.00

- Maximum Power, Pmax = 8.549 watt

Maximum Efficiency increase:

- Aluminum Reflector: 38.01%
- Stainless steel Reflector: 21.58%
- White foam Reflector: 22.63%

Appendix "F"
All data of 55°
Cloudy Weather (summer)

DATE-06.08.2010
Day-FRIDAY
Table 4.1: **Solar Panel data (Cloudy day)**

Time	Voc	Isc	Power, P	Weather
8.00	13.91	0.004	0.056	cloudy
8:30	14.09	0.009	0.085	cloudy
9:30	14.57	0.009	0.131	cloudy
10:15	16.06	0.012	0.193	cloudy
11.00	16.36	0.010	0.163	cloudy
12:00	16.78	0.016	0.268	cloudy
01:00	17.99	0.022	0.396	cloudy
02:00	17.78	0.032	0.569	cloudy
03:00	17.38	0.028	0.486	cloudy
03:45	13.24	0.003	0.039	cloudy
04:30	15.91	0.009	0.143	cloudy
05:30	16.60	0.015	0.249	cloudy
06.15	10.57	0.000	0.000	cloudy
06.30	09.58	0.000	0.000	cloudy

Maximum Open Circuit Voltage, Voc = 18.28
Maximum Short Circuit Current, Isc = 0.038
Maxium Power, Pmax = 0.681

Day-FRIDAY
Angle-55
Reflector Type- Aluminium
Reflector position-North-South
Table: 4.2

Time	Voc	Isc	Power, P	Weather
8.00	14.12	0.005	0.0706	cloudy
8:30	14.32	0.007	0.10024	cloudy
9:30	14.60	0.009	0.131	cloudy
10:15	16.33	0.013	0.212	cloudy
11.00	16.97	0.019	0.322	cloudy
12:00	16.79	0.016	0.269	cloudy
01:00	18.28	0.028	0.512	cloudy
02:00	17.93	0.038	0.681	cloudy
03:00	17.31	0.028	0.485	cloudy
03:45	13.44	0.005	0.067	cloudy
04:30	15.98	0.009	0.144	cloudy
05:30	16.62	0.017	0.285	cloudy
06.15	10.37	0.000	0.000	cloudy
06.30	09.58	0.000	0.000	cloudy

Maximum Open Circuit Voltage, Voc = 18.28
Maximum Short Circuit Current, Isc = 0.038
Maximum Power, Pmax = 0.681

DATE-06.08.2010
Day-Friday
Angle-55
Reflector Type-Stainless Steel
Reflector position-North-South
Table: 4.3

Time	Voc	Isc	Power, P	Weather
8.00	14.17	0.005	0.071	cloudy
8:30	14.31	0.007	0.100017	cloudy
9:30	14.39	0.008	0.115	cloudy
10:15	16.33	0.009	0.147	cloudy
11.00	16.66	0.017	0.283	cloudy
12:00	16.79	0.016	0.268	cloudy
01:00	18.07	0.023	0.416	cloudy
02:00	17.91	0.038	0.681	cloudy
03:00	17.37	0.029	0.504	cloudy
03:45	13.37	0.004	0.054	cloudy
04:30	16.27	0.012	0.229	cloudy
05:30	16.67	0.018	0.300	cloudy
06.15	10.57	0.000	0.000	cloudy
06.30	09.58	0.000	0.000	cloudy

Maximum Open Circuit Voltage, Voc = 18.07
Maximum Short Circuit Current, Isc = 0.038
Maximum Power, Pmax = 0.681

DATE-06.08.2016
Day-Friday
Angle-55
Reflector Type-White Foam
Reflector position-North-South
Table: 4.4

Time	Voc	Isc	Power, P	Weather
8.00	14.18	0.006	0.085	cloudy
8:30	14.29	0.007	0.1003	cloudy
9:30	14.52	0.006	0.087	cloudy
10:15	16.37	0.015	0.245	cloudy
11.00	16.81	0.018	0.303	cloudy
12:00	16.81	0.017	0.286	cloudy
01:00	18.27	0.027	0.493	cloudy
02:00	17.93	0.038	0.681	cloudy
03:00	17.32	0.028	0.485	cloudy
03:45	13.39	0.004	0.054	cloudy
04:30	16.37	0.014	0.229	cloudy
05:30	16.67	0.018	0.300	cloudy
06.15	10.42	0.000	0.000	cloudy
06.30	09.56	0.000	0.000	cloudy

Maximum Open Circuit Voltage, Voc = 18.27
Maximum Short Circuit Current, Isc = 0.038
Maximum Power, Pmax = 0.681

Day-: Friday
Angle: 55
Weather: Cloudy

Table: 4.5: Efficiency increase rate of different Reflector:

Time	Power (watt) without Reflector	Power (watt) with Aluminum Reflector	%increase	Power(watt) with White Foam Reflector	%increase	Power(watt) with Stainless Steel Reflector	%increase
8.00am	0.056	0.0706	26.07	0.085	51.78	0.071	26.786
8:30am	0.085	0.10024	18.627	0.1003	18.379	0.100017	18.363
9:30am	0.131	0.131	-0.099	0.087	-33.65	0.115	-12.209
10:15am	0.193	0.212	10.004	0.245	27.205	0.147	-23.739
11.00am	0.163	0.222	36.196	0.203	23.54	0.201	23.13
12:00pm	0.268	0.269	0.089	0.286	6.471	0.268	0.000
01:00pm	0.396	0.512	29.308	0.493	24.633	0.416	5.003
02:00pm	0.569	0.681	19.757	0.681	19.757	0.681	19.634
03:00pm	0.486	0.485	-0.288	0.485	-0.214	0.504	3.648
03:45pm	0.397	0.57	43.57	0.540	36.020	0.540	34.844
04:30pm	0.143	0.146	0.699	0.144	0.699	0.144	0.699
05:30pm	0.249	0.283	13.65	0.300	20.482	0.300	20.506
06.15pm	0.000	0.000	0.000	0.000	0.000	0.000	0.000
06.30pm	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Maximum Power Pmax: 0.681 W
Maximum Efficiency increase-

- Aluminum: 43.57%
- Stainless Steel: 36.020%
- White Foam: 34.844%

Appendix "G"
All data of 55°
Sunny Weather (winter)

DATE-10.10.10
Day-Monday
Angle-55
With reflector-Without Reflector
Reflector position-North-South

Time	Voc	Isc	Power, P	Weather
8:00	14.52	0.011	0.1597	sunny
9:00	15.02	0.015	0.2253	sunny
10:00	17.32	0.017	0.2944	sunny
10:30	17.86	0.090	1.6074	sunny
11.00	18.33	0.14	2.5662	sunny
12:00	18.89	0.16	3.0224	sunny
12.30	19.21	0.23	4.4183	sunny
01:00	19.23	0.22	4.2306	sunny
02:00	19.11	0.21	4.0131	sunny
03:00	18.21	0.180	3.2778	sunny
03:30	17.52	0.012	0.2102	sunny
04:00	17.16	0.018	0.3089	sunny
04:30	15.81	0.007	0.1107	sunny
05:00	13.28	0.002	0.0266	sunny
05:30	10.02	0.000	0.000	sunny

Maximum Open Circuit Voltage, Voc = 19.21
Maximum Short Circuit Current, Isc = 0.23
Maxium Power, Pmax = 4.4183

DATE-10.10.10
Day-Sunday
Angle-55
With reflector-Aluminium
Reflector position-North-South

Time	Voc	Isc	Power, P	Weather
8:00	14.69	0.014	0.20566	sunny
9:00	15.06	0.016	0.2409	sunny
10:00	17.37	0.018	0.3127	sunny
10:30	17.79	0.087	1.5477	sunny
11.00	18.19	0.09	1.6371	sunny
12:00	18.91	0.16	3.0256	sunny
12.30	19.24	0.26	4.9998	sunny
01:00	19.25	0.25	5.0024	sunny
02:00	19.21	0.23	4.4183	sunny
03:00	18.22	0.180	3.2796	sunny
03:30	17.63	0.016	0.2821	sunny
04:00	17.17	0.015	0.2576	sunny
04:30	15.90	0.007	0.1113	sunny
05:00	13.33	0.002	0.0266	sunny
05:30	10.03	0.000	0.000	sunny

Maximum Open Circuit Voltage, Voc = 19.25
Maximum Short Circuit Current, Isc = 0.26
Maxium Power, Pmax = 5.0024

DATE-10.10.10
Day-Monday
Angle-55
With reflector-Stainless Steel
Reflector position-North-South

Time	Voc	Isc	Power, P	Weather
8:00	14.55	0.011	0.16	sunny
9:00	15.09	0.016	0.2414	sunny
10:00	17.34	0.017	0.2948	sunny
10:30	17.89	0.09	1.6101	sunny
11.00	18.30	0.12	2.196	sunny
12:00	18.89	0.16	3.0224	sunny
12.30	19.29	0.25	4.8225	sunny
01:00	19.26	0.23	4.4298	sunny
02:00	19.17	0.28	5.3676	sunny
03:00	18.13	0.17	3.0821	sunny
03:30	17.56	0.013	0.2283	sunny
04:00	17.19	0.019	0.3266	sunny
04:30	15.87	0.008	0.12696	sunny
05:00	13.28	0.002	0.0267	sunny
05:30	10.03	0.000	0.000	sunny

Maximum Open Circuit Voltage, Voc = 19.29
Maximum Short Circuit Current, Isc = 0.28
Maxium Power, Pmax = 5.3676

DATE-10.10.10
Day-Sunday
Angle-55
With reflector-Foam Core
Reflector position-North-South

Time	Voc	Isc	Power, P	Weather
8:00	14.69	0.014	0.20566	sunny
9:00	15.01	0.016	0.2402	sunny
10:00	17.47	0.019	0.3319	sunny
10:30	17.78	0.087	1.5469	sunny
11.00	18.17	0.09	1.6353	sunny
12:00	18.88	0.15	2.832	sunny
12.30	19.28	0.28	5.3984	sunny
01:00	19.25	0.25	4.8175	sunny
02:00	19.21	0.23	4.4183	sunny
03:00	18.24	0.182	3.3197	sunny
03:30	17.64	0.016	0.2822	sunny
04:00	17.18	0.019	0.3264	sunny
04:30	15.84	0.007	0.1109	sunny
05:00	13.35	0.003	0.0401	sunny
05:30	10.03	0.000	0.000	sunny

Maximum Open Circuit Voltage, Voc = 19.28
Maximum Short Circuit Current, Isc = 0.28
Maxium Power, Pmax = 5.3984

DATE-10.10.10
Day-Sunday
Angle-55
With reflector-Standard Reflector
Reflector position-North-South

Time	Voc	Isc	Power, P	Weather
8:00	14.56	0.011	0.1602	sunny
9:00	15.07	0.016	0.2411	sunny
10:00	17.37	0.018	0.3126	sunny
10:30	17.91	0.094	1.6835	sunny
11.00	18.26	0.11	2.0086	sunny
12:00	18.96	0.18	3.4128	sunny
12.30	19.23	0.26	4.9998	sunny
01:00	19.24	0.26	5.0024	sunny
02:00	19.18	0.21	4.0278	sunny
03:00	18.18	0.180	3.2724	sunny
03:30	17.59	0.015	0.2639	sunny
04:00	17.21	0.019	0.3269	sunny
04:30	15.91	0.008	0.1273	sunny
05:00	13.29	0.002	0.0266	sunny
05:30	10.02	0.000	0.000	sunny

Maximum Open Circuit Voltage, Voc = 19.24
Maximum Short Circuit Current, Isc = 0.26
Maxium Power, Pmax = 5.0024

Table: Power Output Increase Rate

Time	Power (watt) without Reflector	Power (watt) with Aluminium Reflector	Power output	Power (watt) with White Foam Reflector	Power output	Power (watt) with Stainless Steel Reflector	Power output	Power (watt) with Standard Reflector	Power output
8.00	0.16	0.21	31.25	0.21	31.25	0.16	0.00	0.16	0.00
9:00	0.22	0.24	9.09	0.24	1.78	0.24	`1.78	0.24	1.78
10:00	0.29	0.31	6.89	0.33	13.79	0.29	0.00	0.31	6.89
10:30	1.61	1.55	-3.73	1.54	-4.34	1.61	0.00	1.68	4.35
11.00	2.57	1.64	-36.19	1.64	-36.19	2.20	-14.39	2.01	-21.79
12:00	3.02	3.03	0.33	2.83	-6.29	3.02	0.00	3.41	12.91
12:30	4.42	4.99	12.89	5.40	22.17	4.82	9.05	4.99	12.89
01:00	4.23	5.00	18.20	4.82	13.95	4.43	4.73	5.00	18.20
02:00	4.01	4.42	10.22	4.42	10.22	5.37	33.91	4.03	0.49
03:00	3.28	3.28	0.00	3.32	1.22	3.08	-6.09	3.27	-0.30
03:30	0.21	0.28	33.34	0.28	33.34	0.23	9.52	0.26	23.81
04:00	0.21	0.26	23.80	0.33	57.14	0.33	57.14	0.33	57.14
04.30	0.11	0.11	0.00	0.11	0.00	0.13	18.18	0.13	18.18
05.00	0.03	0.03	0.00	0.04	33.30	0.03	0.00	0.03	0.00
05:30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Appendix "H"
All data of 55°
Cloudy Weather (winter)

DATE- 01-11-2010
Day- Tuesday
Angle-55
With reflector- Foam Core
Reflector position-North-South

Time	Voc	Isc	Power, P	Weather
8:30	15.31	0.006	0.0919	cloudy
9:00	16.66	0.012	0.1999	cloudy
10:00	16.97	0.013	0.2206	cloudy
11.00	16.88	0.012	0.203	cloudy
12.00	17.59	0.021	0.3694	cloudy
1:00	16.27	0.009	0.1464	cloudy
2:00	15.91	0.007	0.1114	cloudy
3:00	14.75	0.004	0.059	cloudy
3:30	14.69	0.004	0.0588	cloudy
4:00	14.29	0.003	0.0429	cloudy
5:00	9.93	0.000	0.000	cloudy

Maximum Open Circuit Voltage, Voc = 17.59
Maximum Short Circuit Current, Isc = 0.021
Maxium Power, Pmax = 0.3694

DATE- 01-11-2010
Day- Tuesday
Angle-55
With reflector- Aluminum
Reflector position-North-South

Time	Voc	Isc	Power, P	Weather
8:30	15.27	0.006	0.0916	cloudy
9:00	16.63	0.012	0.1996	cloudy
10:00	16.98	0.013	0.2207	cloudy
11.00	16.90	0.012	0.203	cloudy
12.00	17.62	0.022	0.3876	cloudy
1:00	16.20	0.009	0.1458	cloudy
2:00	15.78	0.006	0.0947	cloudy
3:00	14.65	0.004	0.0586	cloudy
3:30	14.67	0.004	0.0587	cloudy
4:00	14.27	0.003	0.0428	cloudy
5:00	9.95	0.000	0.000	cloudy

Maximum Open Circuit Voltage, Voc = 17.62
Maximum Short Circuit Current, Isc = 0.022
Maxium Power, Pmax = 0.3876

DATE- 01-11-2010
Day- Tuesday
Angle-55
With reflector- Stainless Steel
Reflector position-North-South

Time	Voc	Isc	Power, P	Weather
8:30	15.32	0.006	0.0919	cloudy
9:00	16.58	0.011	0.1824	cloudy
10:00	16.93	0.013	0.2201	cloudy
11.00	16.91	0.012	0.203	cloudy
12.00	17.63	0.022	0.3879	cloudy
1:00	16.19	0.009	0.1465	cloudy
2:00	15.87	0.006	0.0952	cloudy
3:00	14.73	0.004	0.0589	cloudy
3:30	14.70	0.004	0.0588	cloudy
4:00	14.37	0.004	0.0574	cloudy
5:00	9.99	0.000	0.000	cloudy

Maximum Open Circuit Voltage, Voc = 17.63
Maximum Short Circuit Current, Isc = 0.022
Maxium Power, Pmax = 0.3879

Day- Tuesday
Angle-55
With reflector- Foam Core
Reflector position-North-South

Time	Voc	Isc	Power, P	Weather
8:30	15.31	0.006	0.0919	cloudy
9:00	16.66	0.012	0.1999	cloudy
10:00	16.97	0.013	0.2206	cloudy
11.00	16.88	0.012	0.203	cloudy
12.00	17.59	0.021	0.3694	cloudy
1:00	16.27	0.009	0.1464	cloudy
2:00	15.91	0.007	0.1114	cloudy
3:00	14.75	0.004	0.059	cloudy
3:30	14.69	0.004	0.0588	cloudy
4:00	14.29	0.003	0.0429	cloudy
5:00	9.93	0.000	0.000	cloudy

Maximum Open Circuit Voltage, Voc = 17.59
Maximum Short Circuit Current, Isc = 0.021
Maxium Power, Pmax = 0.3694

DATE- 01-11-2010
Day- Tuesday
Angle-55
With reflector- Standard Reflector
Reflector position-North-South

Time	Voc	Isc	Power, P	Weather
8:30	15.35	0.006	0.0921	cloudy
9:00	16.59	0.011	0.1825	cloudy
10:00	16.97	0.013	0.2206	cloudy
11.00	16.92	0.012	0.203	cloudy
12.00	17.61	0.022	0.3874	cloudy
1:00	16.31	0.010	0.1631	cloudy
2:00	15.87	0.006	0.0952	cloudy
3:00	14.76	0.004	0.0590	cloudy
3:30	14.69	0.004	0.0588	cloudy
4:00	14.30	0.003	0.0429	cloudy
5:00	9.91	0.000	0.000	cloudy

Maximum Open Circuit Voltage, Voc = 17.61
Maximum Short Circuit Current, Isc = 0.022
Maxium Power, Pmax = 0.3874

Angle- 55
Weather: cloudy
Date: 01-11-2010
Table: Power Output Increase Rate

Time	Power (watt) without Reflector	Power (watt) with Aluminium Reflector	Power output	Power (watt) with White Foam Reflector	Power output	Power (watt) with Stainless Steel Reflector	Power output	Power (watt) with Standard Reflector	Power output
8.30	0.0917	0.0916	-0.109	0.0919	0.218	0.0919	0.218	0.0921	0.436
9:00	0.1711	0.1996	16.657	0.1999	16.832	0.1824	6.604	0.1825	6.663
10:00	0.2207	0.2207	0.000	0.2206	0.045	0.2201	-0.272	0.2206	-0.045
11.00	0.202	0.203	0.495	0.203	0.495	0.203	0.495	0.203	0.495
12:00	0.3885	0.3876	-0.232	0.3694	-4.916	0.3879	-0.154	0.3874	-0.283
01:00	0.1457	0.1458	0.069	0.1464	0.480	0.1465	0.549	0.1631	11.942
02:00	0.0945	0.0947	0.212	0.1114	17.884	0.0952	0.741	0.0952	0.741
03:00	0.0584	0.0586	0.342	0.059	1.027	0.0589	0.856	0.0590	1.027
03:30	0.0588	0.0587	-0.170	0.0588	0.000	0.0588	0.000	0.0588	0.000
04:00	0.0428	0.0428	0.000	0.0429	0.234	0.0574	34.112	0.0429	0.234
05.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Appendix "I"
All data of 65°
Sunny Weather (summer)

Angle: 65 degree
Without Reflector

Table: 5.1

Time	Voc(V)	Isc(A)	Power(Watt)	Weather condition
8.00	18.80	0.115	2.162	Sunny
8.30	18.50	0.150	2.775	Sunny
9.00	18.76	0.130	2.4388	Sunny
9.30	19.31	0.250	4.8275	Sunny
10.30	19.50	0.252	4.914	Sunny
11.00	19.01	0.297	5.646	Sunny
12.00	18.76	0.230	4.315	Sunny
1.00	18.88	0.284	5.362	Sunny
2.00	18.97	0.230	4.3631	Sunny
3.00	18.86	0.220	4.1419	Sunny
4.00	18.64	0.098	1.827	Sunny
4.45	18.48	0.068	1.257	Sunny
5.30	17.54	0.025	0.439	Sunny
6.00	9.80	0.002	0.0196	Sunny
6.45	9.00	0.00	0.00	Sunny

Maximum Open Circuit Voltage, Voc = 19.50 V
Maximum Short Circuit Current, Isc = 0.297 A
Maximum Power, Pmax = 5.362 watt

Angle: 65 degree
Reflector Type: Aluminum
Reflector position: North-south

Table: 5.2

Time	Voc(V)	Isc(A)	Power(Watt)	Weather condition
8.00	19.08	0.116	2.213	Sunny
8.30	18.49	0.152	2.81	Sunny
9.00	18.76	0.130	2.434	Sunny
9.30	19.31	0.250	4.8275	Sunny
10.30	19.50	0.253	4.934	Sunny
11.00	19.54	0.340	6.644	Sunny
12.00	19.05	0.344	6.553	Sunny
1.00	19.23	0.327	6.288	Sunny
2.00	19.24	0.239	4.598	Sunny
3.00	19.01	0.225	4.277	Sunny
4.00	18.79	0.104	1.954	Sunny
4.45	18.44	0.05	0.922	Sunny
5.30	17.5	0.025	0.438	Sunny
6.00	10.05	0.002	0.02	Sunny
6.45	9.00	0.00	0.00	Sunny

Maximum Open Circuit Voltage, Voc = 19.54 V
Maximum Short Circuit Current, Isc = 0.344 A
Maximum Power, Pmax = 6.644 watt

Angle: 65 degree
Reflector Type: Stainless steel
Reflector position: North-south

Table: 5.3

Time	Voc(V)	Isc(A)	Power(Watt)	Weather condition
8.00	19.08	0.116	2.213	Sunny
8.30	18.49	0.152	2.81	Sunny
9.00	18.76	0.130	2.439	Sunny
9.30	18.95	0.250	4.738	Sunny
10.30	19.00	0.252	4.788	Sunny
11.00	19.39	0.329	6.379	Sunny
12.00	18.87	0.245	4.623	Sunny
1.00	19.25	0.322	6.199	Sunny
2.00	19.18	0.241	4.622	Sunny
3.00	18.95	0.223	4.226	Sunny
4.00	18.74	0.102	1.911	Sunny
4.45	18.44	0.044	0.811	Sunny
5.30	17.47	0.025	0.437	Sunny
6.00	10.00	0.002	0.02	Sunny
6.45	9.02	0.00	0.00	Sunny

Maximum Open Circuit Voltage, Voc = 19.39 V
Maximum Short Circuit Current, Isc = 0.329 A
Maximum Power, Pmax = 6.379 watt

DATE-23.07.10
Angle: 65 degree
Reflector Type: White foam
Reflector position: North-south

Table: 5.4

Time	Voc(V)	Isc(A)	Power(Watt)	Weather condition
8.00	19.04	0.121	2.304	Sunny
8.30	18.7	0.153	2.861	Sunny
9.00	18.78	0.133	2.498	Sunny
9.30	18.98	0.247	4.688	Sunny
10.30	19.10	0.250	4.775	Sunny
11.00	19.01	0.297	5.646	Sunny
12.00	18.75	0.229	4.294	Sunny
1.00	19.02	0.310	5.896	Sunny
2.00	19.30	0.245	4.729	Sunny
3.00	18.91	0.227	4.293	Sunny
4.00	18.79	0.107	2.011	Sunny
4.45	18.48	0.047	0.869	Sunny
5.30	17.52	0.025	0.438	Sunny
6.00	10.14	0.002	0.02	Sunny
6.45	9.02	0.00	0.00	Sunny

Maximum Open Circuit Voltage, Voc = 19.30 V
Maximum Short Circuit Current, Isc = 0.310 A
Maximum Power, Pmax = 5.896 watt

Table 5.5: Efficiency increase rate of different reflector.

Time	Power(Watt) Without reflector	Power(Watt) Reflector-Aluminum	%Increase	Power(Watt) Reflector-Stainless steel	%Increase	Power(Watt) Reflector-White Foam	%Increase
8.00	2.162	2.213	2.35%	2.213	2.36%	2.304	6.57%
8.30	2.775	2.81	1.26%	2.81	1.26%	2.861	3.099%
9.00	2.4388	2.434	-0.109%	2.439	.008%	2.498	2.43%
9.30	4.8275	4.8275	0%	4.738	-1.854%	4.688	-2.89%
10.00	4.914	4.934	0.41%	4.788	-2.56%	4.775	-2.83%
11.00	5.646	6.644	17.68%	6.379	12.983%	5.746	1.77%
12.00	4.315	4.553	5.51%	4.623	7.138%	4.694	8.78%
1.00	5.362	6.288	17.27%	6.199	15.61%	5.896	9.958%
2.00	4.3631	4.598	5.38%	4.622	5.93%	4.729	6.824%
3.00	4.1419	4.277	3.26%	4.226	2.03%	4.293	0.386%
4.00	1.827	1.954	6.95%	1.911	4.597%	2.011	10.07%
4.45	1.257	0.922	-26.65%	0.811	-35.48%	0.869	-30.87%
5.30	0.439	0.438	-0.228%	0.437	-0.456%	0.438	-0.228%
6.00	0.0196	0.02	2.04%	0.02	2.04%	0.02	2.04%
6.30	0.00	0.00	0%	0.00	0%	0.00	0%

- Maximum Power, Pmax = 6.644 watt

Maximum Efficiency increase:

- Aluminum Reflector: 17.27%
- Stainless steel Reflector: 15.61%
- White foam Reflector: 10.07%

Appendix "J"
All data of 65°
Cloudy Weather (summer)

Date: 31- 07 -2010
Day: Saturday
Angle: 65 degree
Without Reflector

Table: 6.1

Time	Voc	Isc	Power, P	Weather
8.00 AM	18.64	0.048	0.895	Cloudy
8.30 AM	18.67	0.054	1.0082	Cloudy
9.00 AM	19.14	0.094	1.799	Cloudy
9.45 AM	19.36	0.190	3.68	Cloudy
10.30 AM	19.05	0.120	2.29	Cloudy
11.15 AM	19.14	0.118	2.26	Cloudy
12.30 PM	18.58	0.08	1.49	Cloudy
2.15 PM	18.34	0.059	1.082	Sunny
2.45 PM	18.73	0.074	1.39	Cloudy
3.30 PM	18.44	0.071	1.31	Cloudy
4.30 PM	18.25	0.047	0.86	Cloudy
5.00 PM	18.26	0.042	0.77	Cloudy
5.45 PM	17.30	0.017	0.29	Cloudy
6.15 PM	15.12	0.005	0.08	Cloudy
6.30 PM	12.5	0.002	0.025	Cloudy
6.45 PM	12.5	0.000	0.000	Cloudy

Maximum Open Circuit Voltage, Voc = 19.36 V
Maximum Short Circuit Current, Isc = 0.190 A
Maximum Power, Pmax = 3.68 watt

Date - 31- 07 -2010
Day – Saturday
Angle: 65 degree
Reflector Type: Aluminum
Reflector Position: North-South

Table: 6.2

Time	Voc	Isc	Power, P	Weather
8.00 AM	18.7	0.051	0.954	Cloudy
8.30 AM	18.77	0.057	1.07	Cloudy
9.00 AM	19.22	0.104	1.999	Cloudy
9.45 AM	19.40	0.196	3.8	Cloudy
10.30 AM	19.19	0.136	2.61	Cloudy
11.15 AM	19.18	0.117	2.244	Cloudy
12.30 PM	18.94	0.090	1.71	Cloudy
2.15 PM	18.54	0.065	1.21	Cloudy
2.45 PM	18.80	0.074	1.39	Cloudy
3.30 PM	18.48	0.079	1.46	Cloudy
4.30 PM	18.32	0.048	0.88	Cloudy
5.00 PM	18.30	0.046	0.842	Cloudy
5.45 PM	17.30	0.018	0.3114	Cloudy
6.15 PM	15.46	0.007	0.11	Cloudy
6.30 PM	13.00	0.002	0.026	Cloudy
6.45 PM	13.00	0.000	0.000	Cloudy

Maximum Open Circuit Voltage, Voc = 19.40 V
Maximum Short Circuit Current, Isc = 0.196 A
Maximum Power, Pmax = 3.8 watt

Day – Friday
Angle: 65 degree
Reflector – Stainless Steel
Reflector Position: North-South

Time	Voc	Isc	Power, P	Weather
8.00 AM	18.65	0.046	0.8579	Cloudy
8.30 AM	18.71	0.053	0.99163	Cloudy
9.00 AM	19.14	0.095	1.8183	Cloudy
9.45 AM	19.43	0.191	3.71113	Cloudy
10.30 AM	19.09	0.129	2.46261	Cloudy
11.15 AM	19.22	0.124	2.38328	Cloudy
12.30 PM	19.11	0.114	2.17854	Cloudy
2.15 PM	18.22	0.055	1.0021	Sunny
2.45 PM	18.77	0.074	1.38898	Cloudy
3.30 PM	18.42	0.071	1.30782	Cloudy
4.30 PM	18.32	0.047	0.86104	Cloudy
5.00 PM	18.28	0.042	0.76776	Cloudy
5.45 PM	17.24	0.018	0.31032	Cloudy
6.15 PM	15.23	0.006	0.09138	Cloudy
6.30 PM	12.7	0.002	0.0254	Cloudy
6.45 PM	12.7	0.000	0.000	Cloudy

Day: Saturday
Angle: 65 degree
Reflector Type: Foam Core
Reflector Position: North-South

Table: 6.4

Time	Voc	Isc	Power, P	Weather
8.00 AM	18.68	0.05	0.934	Cloudy
8.30 AM	18.73	0.056	1.04888	Cloudy
9.00 AM	19.20	0.101	1.9392	Cloudy
9.45 AM	19.36	0.190	3.6784	Cloudy
10.30 AM	19.19	0.130	2.4947	Cloudy
11.15 AM	19.32	0.126	2.43432	Cloudy
12.30 PM	19.06	0.114	2.17284	Cloudy
2.15 PM	18.85	0.080	1.508	Sunny
2.45 PM	18.84	0.075	1.413	Cloudy
3.30 PM	18.45	0.075	1.38375	Cloudy
4.30 PM	18.40	0.050	0.92	Cloudy
5.00 PM	18.35	0.043	0.78905	Cloudy
5.45 PM	17.28	0.018	0.31104	Cloudy
6.15 PM	15.12	0.005	0.0756	Cloudy
6.30 PM	12.5	0.002	0.025	Cloudy
6.45 PM	12.5	0.000	0.000	Cloudy

Maximum Open Circuit Voltage, Voc = 19.36 V
Maximum Short Circuit Current, Isc = 0.190 A
Maximum Power, Pmax = 3.7684 watt

Table 6.5: Efficiency Increase rate of different reflector:

Time	Power(Watt) Without reflector	Power(Watt) Reflector-Aluminum	%Increase	Power(Watt) Reflector-Stainless steel	%Increase	Power(Watt) Reflector-White Foam	%Increase
8.00 AM	0.895	0.954	6.592	0.8579	-4.145	0.934	4.358
8.30 AM	1.0082	1.07	5.776	0.99163	-1.644	1.04888	4.028
9.00 AM	1.799	1.999	10.025	1.8183	1.073	1.9392	7.793
9.45 AM	3.68	3.8	3.261	3.71113	0.85%	3.6784	-0.043%
10.30 AM	2.29	2.61	13.974	2.46261	7.54%	2.4947	7.71%
11.15 AM	2.26	2.244	-0.713	2.38328	5.45%	2.43432	7.71%
12.30 PM	1.49	1.71	14.765	2.17854	46.21	2.17284	45.83%
2.15 PM	1.082	1.21	11.83	1.0921	1.09	1.08	0
2.45 PM	1.39	1.39	0.000	1.39	0	1.413	7.86
3.30 PM	1.31	1.46	11.450	1.31	0	1.38375	5.63
4.30 PM	0.86	0.88	2.326	0.86104	0.12	0.92	6.977
5.00 PM	0.77	0.842	9.351	0.778	1.03	0.78905	2.47
5.45 PM	0.29	0.3114	7.379	0.31032	7.007	0.31104	7.2557
6.15 PM	0.08	0.11	37.5	0.09138	14.23	0.0756	-5.5
6.30 PM	0.025	0.026	4.00	0.0254	1.6	0.025	0.000
6.45 PM	0.000	0.000	0.000	0.000	0.000	0.000	0.000

- Maximum Power, Pmax =3.8 watt

Maximum Efficiency increase:

- Aluminum Reflector: 13.974%
- Stainless steel Reflector: 15.61%
- White foam Reflector: 10.07%

Appendix "K"
All data of 65°
Sunny Weather (winter)

DATE- 12-11-2010
Day- Tuesday
Angle-65
With reflector- Without Reflector
Reflector position-North-South

Time	Voc	Isc	Power, P	Weather
8:30	17.09	0.015	0.2564	sunny
9:00	17.29	0.019	0.3285	sunny
10:00	18.21	0.149	2.7133	sunny
11.00	19.57	0.184	3.6009	sunny
12.00	19.78	0.212	4.1934	sunny
1:00	19.87	0.214	4.2522	sunny
2:00	19.49	0.181	3.5277	sunny
2:30	19.20	0.171	3.2832	sunny
3:00	18.41	0.074	1.3623	sunny
3:30	17.71	0.037	0.6553	sunny
4:00	15.31	0.008	0.1225	sunny
5:00	09.91	0.000	0.000	sunny

Maximum Open Circuit Voltage, Voc = 19.87
Maximum Short Circuit Current, Isc = 0.214
Maxium Power, Pmax = 4.2522

DATE- 12-11-2010
Day- Tuesday
Angle-65
With reflector- Aluminum
Reflector position-North-South

Time	Voc	Isc	Power, P	Weather
8:30	17.12	0.016	0.2739	sunny
9:00	17.34	0.020	0.3468	sunny
10:00	18.29	0.151	2.7618	sunny
11.00	19.65	0.185	3.6353	sunny
12.00	19.79	0.212	4.1955	sunny
1:00	19.89	0.214	4.2565	sunny
2:00	19.52	0.182	3.5526	sunny
2:30	19.29	0.173	3.3372	sunny
3:00	18.42	0.074	1.3631	sunny
3:30	18.76	0.039	0.6926	sunny
4:00	15.38	0.009	0.1384	sunny
5:00	09.99	0.000	0.000	sunny

Maximum Open Circuit Voltage, Voc = 19.89
Maximum Short Circuit Current, Isc = 0.214
Maxium Power, Pmax = 4.2565

DATE- 12-11-2010
Day- Tuesday
Angle-65
With reflector- Standard Reflector
Reflector position-North-South

Time	Voc	Isc	Power, P	Weather
8:30	17.10	0.015	0.2565	sunny
9:00	17.36	0.021	0.3646	sunny
10:00	18.26	0.150	2.7390	sunny
11.00	19.62	0.185	3.6297	sunny
12.00	19.84	0.213	4.2259	sunny
1:00	19.82	0.213	4.2217	sunny
2:00	19.61	0.185	3.6279	sunny
2:30	19.21	0.171	3.2849	sunny
3:00	18.42	0.074	1.3631	sunny
3:30	17.72	0.037	0.6556	sunny
4:00	15.34	0.008	0.1227	sunny
5:00	10.05	0.000	0.000	sunny

Maximum Open Circuit Voltage, Voc = 19.84
Maximum Short Circuit Current, Isc = 0.213
Maxium Power, Pmax = 4.2259

DATE- 12-11-2010
Day- Tuesday
Angle-65
With reflector- Stainless Steel
Reflector position-North-South

Time	Voc	Isc	Power, P	Weather
8:30	17.12	0.016	0.2739	sunny
9:00	17.33	0.020	0.3466	sunny
10:00	18.27	0.151	2.7588	sunny
11.00	19.65	0.185	3.6353	sunny
12.00	19.76	0.211	4.1694	sunny
1:00	19.90	0.215	4.2785	sunny
2:00	19.59	0.184	3.6046	sunny
2:30	19.24	0.172	3.3093	sunny
3:00	18.47	0.075	1.3853	sunny
3:30	17.73	0.038	0.6737	sunny
4:00	15.38	0.009	0.1384	sunny
5:00	10.02	0.000	0.000	sunny

Maximum Open Circuit Voltage, Voc = 19.90
Maximum Short Circuit Current, Isc = 0.215
Maxium Power, Pmax = 4.2785

Angle- 65
Weather: Sunny
Date: 12-11-2010
Table: Power Output Increase Rate

Time	Power (watt) without Reflector	Power (watt) with Aluminium Reflector	Power output	Power (watt) with White Foam Reflector	Power output	Power (watt) with Stainless Steel Reflector	Power output	Power (watt) with Standard Reflector	Power output
8.30	0.2564	0.2739	6.825	0.2742	6.9423	0.2739	6.825	0.2565	0.0390
9:00	0.3285	0.3468	5.5708	0.3648	11.05	0.3466	5.509	0.3646	10.989
10:00	2.7133	2.7618	1.7875	2.7603	1.7322	2.7588	1.6769	2.7390	0.9472
11.00	3.6009	3.6353	0.9553	3.6046	0.103	3.6353	0.9553	3.6297	0.7998
12:00	4.1934	4.1955	0.0501	4.1955	0.0501	4.1694	-0.5723	4.2259	0.7750
01:00	4.2522	4.2565	0.101	4.2522	0.000	4.2785	0.6185	4.2217	0.7173
02:00	3.5277	3.5526	0.706	3.6260	2.7865	3.6046	2.1799	3.6279	2.8404
02:30	3.2832	3.3372	1.645	3.3337	1.5381	3.3093	0.795	3.2849	0.0518
03:00	1.3623	1.3631	0.059	1.4052	3.1491	1.3853	1.6883	1.3631	0.0587
03:30	0.6553	0.6926	5.6920	0.6741	2.8689	0.6737	2.8079	0.6556	0.0458
04:00	0.1225	0.1384	12.98	0.1226	0.0816	0.1384	12.98	0.1227	0.1633
05:00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Appendix "L"
All data of 65°
Cloudy Weather (winter)

DATE-17.10.10
Day- Sunday
Angle-65
With reflector-Without Reflector
Reflector position-North-South

Time	Voc	Isc	Power, P	Weather
8:00	19.12	0.12	2.294	cloudy
8:30	19.20	0.136	2.611	cloudy
9:30	18.91	0.07	1.324	cloudy
10:30	19.14	0.13	2.488	cloudy
11.30	18.51	0.078	1.444	cloudy
12:30	17.80	0.044	0.712	cloudy
01:30	19.20	0.06	1.152	cloudy
02:30	19.18	0.061	1.169	Cloudy
03:30	18.37	0.05	0.919	Cloudy
04:30	16.30	0.04	0.652	cloudy
05:00	16.20	0.01	0.162	cloudy
05:30	16.01	0.001	0.016	cloudy

Maximum Open Circuit Voltage, Voc = 19.20
Maximum Short Circuit Current, Isc = 0.136
Maxium Power, Pmax = 2.611

DATE-17.10.10
Day-Sunday
Angle-65
With reflector- Aluminum
Reflector position-North-South

Time	Voc	Isc	Power, P	Weather
8:00	19.00	0.129	2.451	cloudy
8:30	19.08	0.13	2.48	cloudy
9:30	19.05	0.082	1.562	cloudy
10:30	19.20	0.09	1.728	cloudy
11.30	18.64	0.085	1.584	cloudy
12:30	17.76	0.041	0.728	cloudy
01:30	18.50	0.079	1.462	cloudy
02:30	19.16	0.067	1.284	Cloudy
03:30	18.34	0.053	0.972	Cloudy
04:30	17.82	0.04	0.713	cloudy
05:00	16.32	0.01	0.163	cloudy
05:30	16.20	0.001	0.016	cloudy

Maximum Open Circuit Voltage, Voc = 19.20
Maximum Short Circuit Current, Isc = 0.13
Maxium Power, Pmax = 2.48

DATE-17.10.10
Day-Sunday
Angle-65
With reflector- Foam Core
Reflector position-North-South

Time	Voc	Isc	Power, P	Weather
8:00	19.01	0.082	1.559	cloudy
8:30	19.21	0.132	2.536	cloudy
9:30	18.67	0.056	1.046	cloudy
10:30	19.09	0.12	2.291	cloudy
11.30	18.60	0.081	1.507	cloudy
12:30	17.77	0.042	0.746	cloudy
01:30	19.25	0.081	1.559	cloudy
02:30	19.18	0.065	1.247	Cloudy
03:30	18.30	0.05	0.915	Cloudy
04:30	17.89	0.042	0.751	cloudy
05:00	16.36	0.01	0.164	cloudy
05:30	16.1	0.001	0.016	cloudy

Maximum Open Circuit Voltage, Voc = 19.25
Maximum Short Circuit Current, Isc = 0.132
Maxium Power, Pmax = 2.536

DATE-17.10.10
Day-Sunday
Angle-65
With reflector-Stainless Steel
Reflector position-North-South

Time	Voc	Isc	Power, P	Weather
8:00	19.00	0.08	1.52	cloudy
8:30	19.15	0.10	1.915	cloudy
9:30	18.59	0.043	0.799	cloudy
10:30	19.01	0.09	1.71	cloudy
11.30	18.54	0.079	1.464	cloudy
12:30	17.63	0.038	0.67	cloudy
01:30	19.20	0.07	1.34	cloudy
02:30	19.16	0.062	1.188	Cloudy
03:30	18.28	0.05	0.914	Cloudy
04:30	18.10	0.04	0.724	cloudy
05:00	16.35	0.01	0.164	cloudy
05:30	16.01	0.001	0.016	cloudy

Maximum Open Circuit Voltage, Voc = 19.20
Maximum Short Circuit Current, Isc = 0.10
Maxium Power, Pmax = 1.915

Day-Sunday
Angle-65
With reflector- Standard Reflector
Reflector position-North-South

Time	Voc	Isc	Power, P	Weather
8:00	19.05	0.13	2.477	cloudy
8:30	19.10	0.15	2.865	cloudy
9:30	18.9	0.08	1.512	cloudy
10:30	19.13	0.089	1.703	cloudy
11.30	18.7	0.09	1.683	cloudy
12:30	17.79	0.042	0.747	cloudy
01:30	19.02	0.08	1.522	cloudy
02:30	19.17	0.067	1.284	Cloudy
03:30	18.36	0.052	0.955	Cloudy
04:30	18.30	0.048	0.878	cloudy
05:00	16.35	0.01	0.164	cloudy
05:30	16.1	0.001	0.016	cloudy

Maximum Open Circuit Voltage, Voc = 19.17
Maximum Short Circuit Current, Isc = 0.15
Maximum Power, Pmax = 2.865

Angle: 65
Weather: Cloudy
Table: Power output increase rate

Time	Power, P without Reflector	Power, P Aluminum	Power output(%)	Power, P Stainless steel	Power output(%)	Power, P Standard Reflector	Power output(%)	Power, P foam	Power output(%)
8:00	2.294	2.451	6.844	1.52	-33.740	2.477	7.977	1.559	-32.040
8:30	2.611	2.48	-5.017	1.915	-26.65	2.865	9.728	2.536	2.872
9:30	1.324	1.562	17.976	0.799	-39.653	1.512	14.199	1.046	-20.997
10:30	2.488	1.728	-30.547	1.71	-31.270	1.703	-31.55	2.291	-7.944
11.30	1.444	1.584	9.695	1.464	1.385	1.683	16.551	1.507	4.363
12:30	0.712	0.728	2.247	0.67	-5.899	0.747	4.915	0.746	4.775
01:30	1.152	1.462	26.909	1.34	16.319	1.522	32.118	1.559	35.329
02:30	1.169	1.284	9.837	1.188	1.625	1.284	9.837	1.247	6.672
03:30	0.919	0.972	5.767	0.914	-0.544	0.955	3.917	0.915	-0.435
04:30	0.652	0.713	9.356	0.724	11.043	0.878	34.663	0.751	15.184
05:00	0.162	0.163	0.617	0.164	1.235	0.164	1.235	0.164	1.235
05:30	0.016	0.016	0.00	0.016	0.00	0.016	0.00	0.016	0.00