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Comparison and Optimization of Concentrating Solar Collector PV Panel Employing a Tracking Gadget

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Abstract – **Our Project "Comparison and optimization of concentrating solar collector PV Panel Employing a Tracking Gadget". This Project is based on the comparison between the power generated using concentrating type solar collector with solar tracking and power generated by a simple PV panel. As the power obtained of PV panel exposed directly onto the sunlight is less, concentrating type solar collector is used for power generation .The solar collector is rotated according to Sun's direction by using Servo motor which is controlled by arduino. During a normal day sun will move approximately 13^0 to 15^0 per hour. The arduino is programmed in such a way that it controls servo motor movement which in turn rotates the collector by 15^0 per hour. The surface of the collector is pasted with silvered mirror which has high tendency to reflect light. The reflected light from the collector concentrates onto the PV panel which is placed at an appropriate focal height from the dish, so power is produced. The power generated by this type is more than conventional type power generation. We are comparing the power obtained at three different latitude and longitude positions.**

Keywords: **CSP, Photovoltaic, Arduino, Servo motor, parabolic dish, Multimeter**

I. INTRODUCTION

As the world's supply of fossil fuels shrinks, there is a great need for clean and affordable renewable energy sources in order to meet growing energy demands. Achieving sufficient supplies of clean energy for the future is a great societal challenge. Sunlight, the largest available carbon-neutral energy source provides the earth with more energy in one hour than is consumed on the planet in an entire year. Despite of this, solar electricity currently provides only a fraction of present of world's power consumption A great deal of research is put into the harvest and storage of solar energy for power generation. There are two mainstream categories of devices utilized for this purpose-Photovoltaic and concentrated solar power (CSP). The former involves the use of solar cells to generate electricity directly via the photoelectric effect. The latter employs different method of capturing solar thermal energy for use in power-producing heat processes. Collectors can be classified broadly into two main types – flat plate collectors and concentrating solar collectors. The main advantage of concentrated collectors over flat plate collectors is that the cost of installation and the floor space requirement is high compared to concentrated collectors. Concentrated solar power has been under investigation for several decades, and is based on a simple general scheme: using mirrors, sunlight can be redirected, focused and absorbed by the photovoltaic panel. There are many types of concentrated solar collector available for concentrating light, such as Parabolic through collector, Minor strip reflector, Fresnel strip collector, Compound parabolic concentrator. Out of these concentrated collectors parabolic type is very easy to fabricate and very effective too.

A. *Objective*

- To create awareness among the people about pollution free power generation.
- To generate power using our planet's big renewable resource that is sun's energy.
- To obtain maximum power by the available sun's energy.
- To show the difference between power obtained by ordinary solar panel and power obtained by concentrated solar collector.
- To move the concentrated collector according to the sun's movement.
- To steady about electronic components like arduino for the movement of collector
- To use arduino for the control of mechanical components.
- To fabricate the kit for power generation with available simple components.

B. *Literature Review*

The innovative aspect of CSP is that it captures and concentrates the sun's energy to provide the heat required to generate electricity, rather than using fossil fuels or nuclear reactions. Another attribute of CSP plants is that they can be equipped with a heat storage system in order to generate electricity even when the sky is cloudy or after sunset. [2]This significantly increases the CSP capacity factor compared with solar photovoltaic and more importantly, enables the production of dispatch able electricity, which can facilitate both grid integration and economic competitiveness. CSP technologies therefore benefit from advances in solar concentrator and thermal storage technologies. While other components of the CSP plants are based on rather mature technologies and cannot expect to see rapid cost reductions.

The main objective of this paper is to show the potential use of a solar panel using multiple fixed directed mirrors as a reflector. The solar panel only receives direct beam of sunlight and diffused sunlight. [12]Experiment shows that if we use reflector (mirror) to concentrate sunlight onto PV panels, each individual panel receives a lot of additional power. As a result, the number of solar panels needed to produce a certain amount of power can be reduced, and the money spent on ordinary solar trackers which are more expensive than reflectors is saved. This therefore, is a cost-effective way. [10]With the help of multimeter we recorded the received power of a photovoltaic solar panel using reflector (mirror) and without using reflector and compared this for calculating the performance of a panel. Different assumptions are taken to make the system realistic and to reduce the complexity
.

The sun enough energy from the sun falls on the Earth every day to power our homes and businesses for almost 30 years. You may have heard about solar electric power to light homes or solar thermal power used to heat water,[9] Central receivers (or power towers) use thousands of individual sun-tracking mirrors called "heliostats" to reflect solar energy onto a receiver located on top of a tall tower.

This paper designed an innovative taper annulus structure for the solar dish cavity receiver based on the optical principle analysis of dish parabolic collector and the mathematic model. [13] In the paper, the mathematic model of solar dish optic geometry is established to predict the radiation flux distribution of a cylinder cavity receiver. At the same time, the size of collector and receiver is calculated.

The control circuit is based on an ATMega328P microcontroller. It was programmed to detect sunlight via the LDRs before actuating the servo to position the solar panel. [4]The solar panel is positioned where it is able to receive maximum light. As compared to other motors, the servo motors are able to maintain their torque at high speed. They are also more efficient with efficiencies in the range of 80-90%. Servos can supply roughly twice their rated torque for short periods. They are also quiet and do not vibrate or suffer resonance issues. Performance and characteristics of solar panels are analysed experimentally.

Solar energy is the energy generated by harnessing the power of solar radiation. The maximum intensity of solar radiation at the earth's surface is about1.2 kW/m^2 but it is encountered only near the equator on clear days at noon. Under these ideal conditions, [1] the total energy received is from 6-8 kW h/m^2 per day.. The use of sunlight directly as an energy source has proved in the past to be less economical than the use of these other sources of concentrated [7] sunshine in the forms of solar energy collectors. Solar collectors developed over the year can be categorized as concentrating or focusing collectors, flat plate collectors, solar ponds and photovoltaic panels.

The solar tracking mobility platform plays a crucial role in the development of solar energy applications, [11] especially in high temperature solar concentration systems that directly convert the solar energy into thermal or electrical energy. In these systems, high precision tracking is required to ensure that the solar collector is capable of harnessing the maximum amount of [4] solar energy throughout the day. In order to maintain high levels of power output, a high-precision sun-tracking system or solar tracking mobility platform is necessary to follow the sun on its trajectory as it moves across the sky.

II. Specification Of Problem

In India, still there are number of villages where there is no electricity. Electricity which has become mandatory one for every human being is still a nightmare for many village peoples in our country. A country will become a developed one when all the people in the country enjoy all their basic needs. Electricity is also one of the basic needs. So lack of electricity in villages creates a problem for India becoming a developed country.

In India only 4% of power production is shared by solar power [6].In India Average of about 300 clear, sunny days in a year [7]. Although having this much of nature solar power, our power production using solar power is not up to the mark. After some years, that is after the extinction of the non-renewable power producers like fossil energies, solar will become one of the sole power producer.

By nature these villages have abundant solar source. By simply installing a photovoltaic panel the amount of power obtained is very small. Therefore, in this case concentrated type solar collector for power generation will be handy. Comparatively from the Non-renewable power production process, solar energy is the one of the clean energy of renewable energy. Another advantage of using his method is that it can be easily installed and the maintenance cost is also less. So that by implementing this project in villages India's problem of becoming developed country can be resolved.

III. PROCESS INVOLVED

The basic principle of concentrated type solar collector is that sunlight falls on the concentrated type solar collector where it is concentrated or focused into the photovoltaic panel, the concentrated light falling upon the photovoltaic panel is absorbed by the panel and the light energy is get converted into electrical energy.

A. *How the Tracker Follow the Sun*

- Sun Rise "Wake Up" The Track Rack begins the day facing east. As the morning sun rises, the sun rays falls dish, servo motor to turn towards the direction (at approximately 0.25degree per minute).
- Mid- Morning As the sun rises, where it's getting maximum efficiency and correspondingly moves towards that direction. To run in the servo motor rotates constant speed.
- Mid- Afternoon As the sun moves, the Track Rack follow (at approximately 15degree per hour) continually moving from one side to another.
- Sunset The Tracking angle completes its daily cycle rotation revetment west. It remains in this position nightlong until it is "arouse" by the rising sun the following morning.

B. *Working*

Our project "concentrating solar collector for power generation with solar tracking " is based on the fact that when sun light falls on the collectors surface it will get reflected onto the solar panel which is placed at an appropriate distance from the panel.

The solar collector is made to move according to the sun's movement so that we can able to get more power being generated. To achieve this the solar collector is linked with the servo motor at one end and the other end is attached to the face in such a way that it will rotate freely. The servo end side will be powered by servo motor and it will be controlled by arduino.

The arduino which is nothing but a device which functions similar to the microcontroller the arduino is programmed to control the servo motor.

Approximately sun will move at a distance of 15 degree per hour from east to west. So it is clear that if the collector is rotated at 15 degree per hour then we will able to generate more power. The arduino is programmed in such a way that it will control the servo motor to shift the collector at 15 degree per hour. Solar panel is placed at a distance from the collect with the help of welding.

At the start of the day the collector is made to face the west direction and at 6.00 am the setup is made to start and it will rotate 15 degree per hour and power will be obtained simultaneously.

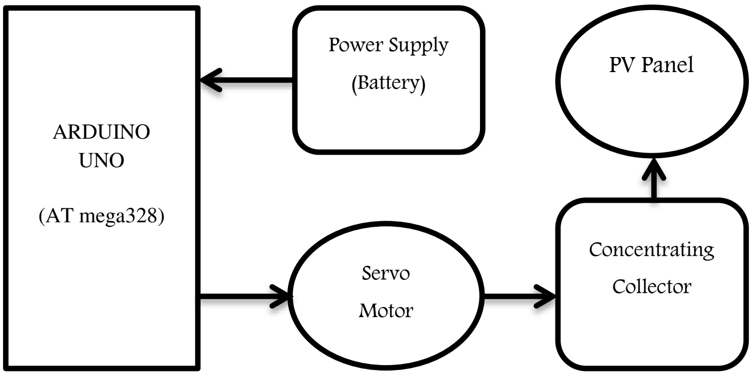


Fig.1.Working Block Diagram

The Fig.1 shows a working process of the concentrating solar collector rotates and controlled by using the Arduino Uno (AT mega328).

IV. CALCULATION

A. *Specification of the collector and frame*

- Diameter of the collector : 550mm
- Depth of the collector : 55mm
- Dimensions : 140x115x2mm
- Length of the frame : 780mm
- Breath of the frame : 380mm

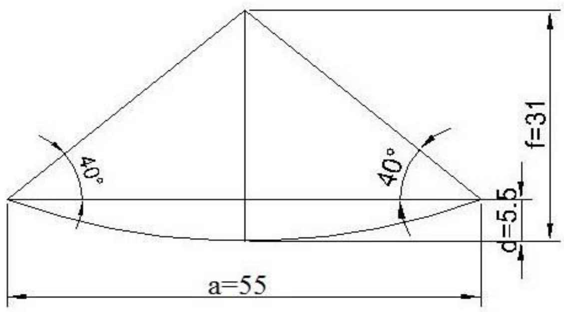


Fig.2. Parabolic dish

Simplify to obtain the [11] equation of the parabola involving the focal distance f.

$$y = \frac{x^2}{4f} \quad (1)$$

We now look at a more practical situation where we know the dimensions of the dish and we want to find the focal distance which gives the positions of the focus relative to the position of the dish as shown in Fig 2.

This gives relationship between the diameter "D" the depth "d" and the focal distance "f" of the dish.

$$f = \frac{D^2}{16d} \qquad (2)$$

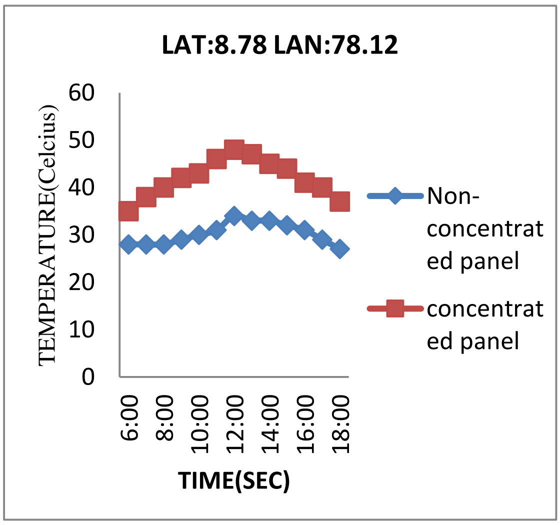
The above formula helps in positioning the feed of the parabolic dish as it gives the focal distance "f".

V. Result And Discussion

TABLE 1

RECEIVED DATA OF A PV SOLAR PANEL USING SILVERED MIRROR PAPER AS REFLECTOR AND WITHOUT USING REFLECTOR (Latitude $8^0 78^0$ and Longitude $78^0 12^0$ Position)

TIME	VOLTAGE(V)		CURRENT(A)		POWER(W)		TEMPARATURE(^{0}C)	
	NON-CONCENRATED PANEL	CONCENTRATED PANEL	NON-CONCENRATED PANEL	CONCENTRATED PANEL	NON-CONCENRATED PANEL	CONCENTRATED PANEL	NON-CONCENRATED PANEL	CONCENTRATED PANEL
06:00	8.54	9.6	0.025	0.028	0.2135	0.2688	28	35
07:00	9.22	10.12	0.027	0.03	0.2489	0.3036	28	38
08:00	12.4	12.92	0.035	0.038	0.434	0.4909	28	40
09:00	13.17	13.4	0.036	0.04	0.4741	0.536	29	42
10:00	13.48	13.52	0.039	0.043	0.5257	0.5814	30	43
11:00	13.59	13.62	0.042	0.047	0.5708	0.6401	31	46
12:00	13.7	13.95	0.052	0.055	0.7124	0.7673	34	48
13:00	13.68	13.9	0.05	0.053	0.684	0.7367	33	47
14:00	13.52	13.68	0.047	0.05	0.6354	0.684	33	45
15:00	13.45	13.55	0.045	0.048	0.6053	0.6504	32	44
16:00	12.92	13.29	0.04	0.045	0.5168	0.5981	31	41
17:00	12.57	13.09	0.032	0.039	0.4022	0.5105	29	40
18:00	10.23	11.4	0.03	0.035	0.3069	0.399	27	37



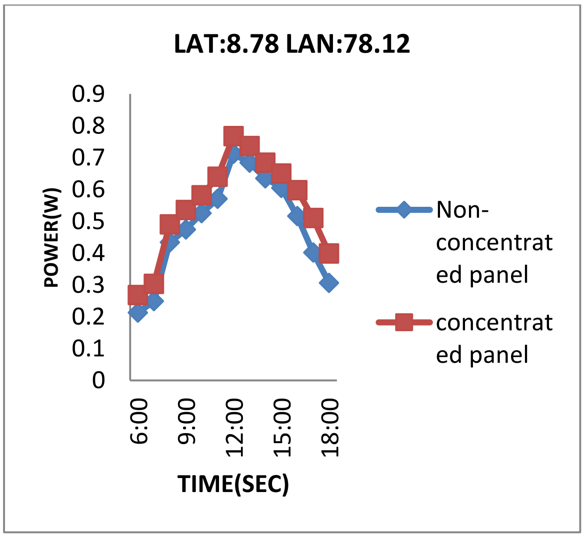


Fig 3 Receive temperature and power non-concentrated panel and concentrated panel

We placed solar panel at the appropriate focal length from the concentrated collector and taken data by using multimeter for a week in March 2018 in the same weather and temperature at Latitude $8^0 78^0$ and Longitude $78^0 12^0$ Position. We used silvered mirror paper as reflector materials to concentrate sunlight onto the panel from the morning to the late afternoon. Using multimeter we took both voltage and current and then calculate the power received by the panel.

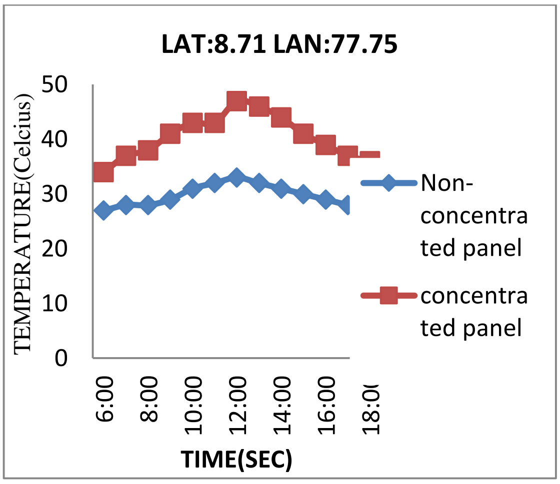
Power (W) = Voltage (V) * Current (A)

Table 1 shows the variation of current, voltage and power of a photovoltaic solar panel using reflector (silvered mirror paper) and without using reflector. We took those values from 6:00 AM to 6:00 PM. The solar panel received maximum 0.7673W and minimum 0.2688W using reflectors.

TABLE 2

RECEIVED DATA OF A PV SOLAR PANEL USING SILVERED MIRROR PAPER AS REFLECTOR AND WITHOUT USING REFLECTOR (Latitude $8^0 71^0$ and Longitude $77^0 7^0$ Position)

TIME	VOLTAGE(V)		CURRENT(A)		POWER(W)		TEMPARATURE(^{0}C)	
	NON-CONCENRATED PANEL	CONCENTRATED PANEL	NON-CONCENRATED PANEL	CONCENTRATED PANEL	NON-CONCENRATED PANEL	CONCENTRATED PANEL	NON-CONCENRATED PANEL	CONCENTRATED PANEL
06:00	8.32	9.52	0.022	0.025	0.183	0.238	27	34
07:00	9.95	10.08	0.028	0.029	0.2786	0.2923	28	37
08:00	12.38	12.8	0.033	0.036	0.4085	0.4608	28	38
09:00	13.15	13.37	0.035	0.038	0.4603	0.5081	29	41
10:00	13.45	13.5	0.038	0.041	0.5111	0.5535	31	43
11:00	13.52	13.61	0.042	0.045	0.5678	0.6125	32	43
12:00	13.68	13.92	0.05	0.053	0.684	0.7378	33	47
13:00	13.67	13.88	0.049	0.05	0.6698	0.694	32	46
14:00	13.49	13.56	0.045	0.048	0.6071	0.6509	31	44
15:00	13.4	13.5	0.04	0.045	0.536	0.6075	30	41
16:00	12.75	13.28	0.032	0.038	0.4845	0.5046	29	39
17:00	12.45	13.1	0.03	0.035	0.3735	0.4585	28	37
18:00	10.08	11.22	0.029	0.032	0.2923	0.3590	27	36



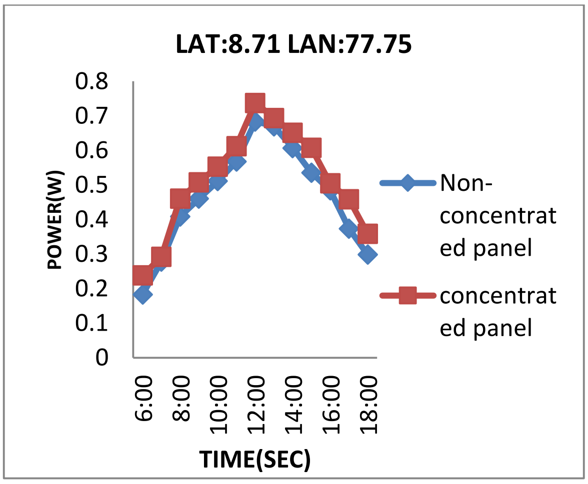


Fig 4 Receive temperature and power non-concentrated panel and concentrated panel

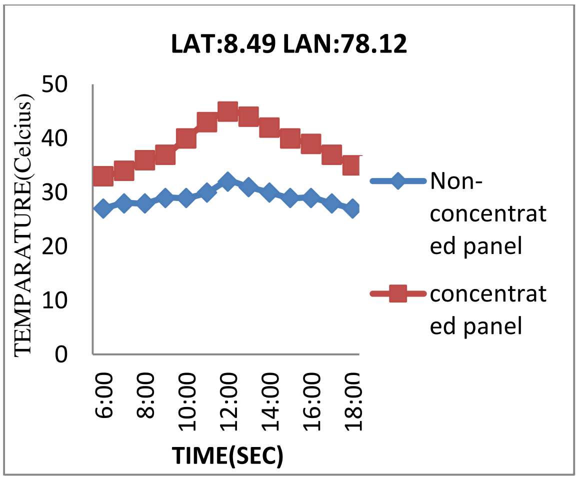
We placed solar panel at the appropriate focal length from the concentrated collector and taken data by using multimeter for a week in March 2018in the same weather and temperature at Latitude $8^{0}71^{0}$ and Longitude $77^{0}7^{0}$ Position. We used silvered mirror paper as reflector materials to concentrate sunlight onto the panel from the morning to the late afternoon. Using multimeter we took both voltage and current and then calculate the power received by the panel.

Table 2 shows the variation of current, voltage and power of a photovoltaic solar panel using reflector (silvered mirror paper) and without using reflector. We took those values from 6:00 AM to 6:00 PM. The solar panel received maximum 0.7378W and minimum 0.2380 W using reflectors.

TABLE 3

RECEIVED DATA OF A PV SOLAR PANEL USING SILVERED MIRROR PAPER AS REFLECTOR AND WITHOUT USING REFLECTOR (Latitude $8^{0}49^{0}$ and Longitude $78^{0}12^{0}$ Position)

TIME	VOLTAGE(V)		CURRENT(A)		POWER(W)		TEMPARATURE(^{0}C)	
	NON-CONCENRATED PANEL	CONCENTRATED PANEL	NON-CONCENRATED PANEL	CONCENTRATED PANEL	NON-CONCENRATED PANEL	CONCENTRATED PANEL	NON-CONCENRATED PANEL	CONCENTRATED PANEL
06:00	8.3	9.4	0.02	0.024	0.166	0.2256	27	33
07:00	9.82	10.05	0.025	0.028	0.2455	0.2814	28	34
08:00	12.35	12.72	0.032	0.036	0.3952	0.4579	28	36
09:00	13.14	13.3	0.033	0.037	0.4336	0.4921	29	37
10:00	13.38	13.45	0.036	0.039	0.4817	0.5246	29	40
11:00	13.5	13.58	0.04	0.045	0.54	0.6111	30	43
12:00	13.67	13.8	0.049	0.052	0.6698	0.7176	32	45
13:00	13.65	13.79	0.048	0.05	0.6552	0.6895	31	44
14:00	13.58	13.65	0.044	0.048	0.5975	0.6552	30	42
15:00	13.4	13.48	0.04	0.044	0.536	0.5931	29	40
16:00	12.62	13.36	0.031	0.04	0.3912	0.5304	29	39
17:00	12.38	13.12	0.028	0.032	0.3466	0.4198	28	37
18:00	9.92	9.97	0.027	0.03	0.2678	0.2991	27	35



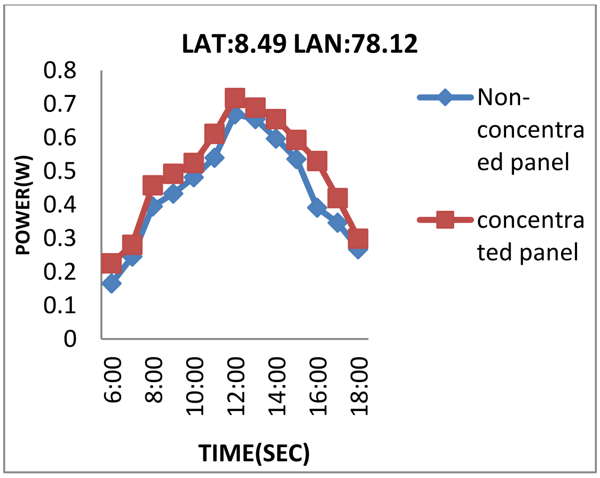


Fig 5 Receive temperature and power non-concentrated panel and concentrated panel

We placed solar panel at the appropriate focal length from the concentrated collector and taken data by using multimeter for a week in March 2018in the same weather and temperature at Latitude $8^0 49^0$ and Longitude $78^0 12^0$ Position. We used silvered mirror paper as reflector materials to concentrate sunlight onto the panel from the morning to the late afternoon. Using multimeter we took both voltage and current and then calculate the power received by the panel.

Table 3 shows the variation of current, voltage and power of a photovoltaic solar panel using reflector (silvered mirror paper) and without using reflector. We took those values from 6:00 AM to 6:00 PM. The solar panel received maximum 0.7176W and minimum 0.2256W using reflectors.

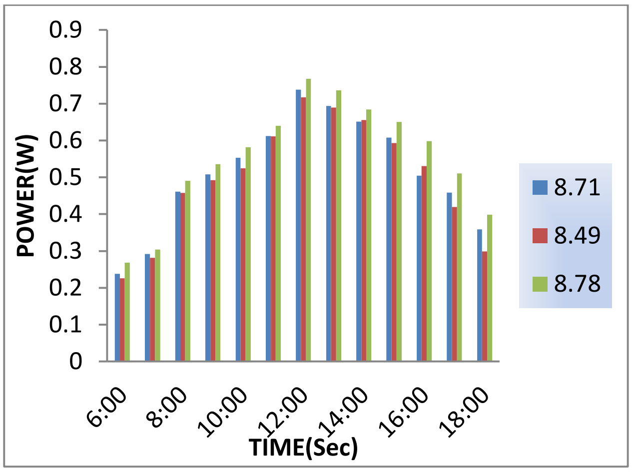


Fig 6 Receive Power Comparison of different longitude position

As we are comparing the power generation a Fig 6 shown in three different latitude and longitude position ($8^0 78^0$, $8^0 71^0$and $8^0 49^0$).We found that the position ($8^0 78^0$) generates more power than the other two.

VI. CONCLUSION

From the simulation of the received power comparison using concentrated Collector and an ordinary PV Panel, We can conclude that the collector plays a vital role in the solar power system for increasing its efficiency. PV Panel using concentrated collector with sun tracking generates large amount of power when compared with direct PV system and this technique also uses maximum possible light energy from the sun by following it throughout the day. By employing this technique in the regions where solar energy is abundant and power transmission is very difficult can get surplus and purest form of energy for their convenient use. Further implementation of LDR sensors and increasing the focal length, power generation will be increased.

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APPENDIX