TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

PULCHOWK CAMPUS

THESIS NO: M-159-MSESP-2020-2023

Evaluation and Comparison of Performance of Solar PV Cell in Different Configurations

by

Subash Wagle

A THESIS

SUBMITTED TO THE DEPARTMENT OF MECHANICAL AND AEROSPACE ENGINEERING IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN ENERGY SYSTEMS PLANNING AND MANAGEMENT

DEPARTMENT OF MECHANICAL AND AEROSPACE ENGINEERING

LALITPUR, NEPAL

APRIL, 2023

COPYRIGHT

TRIBHUVAN UNIVERSITY

INSTITUTE OF ENGINEERING

PULCHOWK CAMPUS

DEPARTMENT OF MECHANICAL AND AEROSPACE ENGINEERING

The undersigned certify that they have read, and recommend to the Institute of Engineering for acceptance, a thesis entitled "**Evaluation and Comparison of Performance of Solar PV Cell in Different Configurations**" submitted by Mr. Subash Wagle in partial fulfillment of the requirements for the degree of Master of Science in Energy Systems Planning and Management.

____

Supervisor, Rajesh Kaji Kayastha
Associate Professor, Department of Mechanical and Aerospace Engineering, Pulchowk Campus

____

External Examiner, Jitendra Kumar Jha
Manager, Planning and Technical Service Division
Nepal Electricity Authority

____

Committee Chairperson, Dr. Surya Prasad Adhikari
Associate Professor, Head of Department,
Department of Mechanical and Aerospace
Engineering, Pulchowk Campus

Date: April 11, 2023

ABSTRACT

This study proposes unique originating design for generating more power by using plane mirror reflection of light propagating towards solar cells of solar photovoltaic systems and usage of air cooling to the PV cells when solar PV cells cross optimal temperature limit. This study provides novel methods for justifying this type of framework outline as well as preliminary findings about the use of a uni-directional reflectance function. In this study, the advantages of employing a plane mirror as a reflector for photovoltaic applications are quantified, as is the usage of a plane mirror in conjunction with solar PV cells that are exposed to air as a cooling medium. Shade, the sun's sporadic nature, and dust reduce the total quantity of incoming radiation on a PV panel, which affects the panel's efficiency. The impact of therefore mentioned problems was minimized by the employment of a plane mirror, which ultimately increases radiation to the solar cells. When solar PV cells are exposed to both direct and reflected light at the same time, their temperature crosses the optimal temperature threshold and efficiency begins to decline. By using a cooling medium, efficiency may be increased once again. The performance of a silicon polycrystalline PV module with a mirror reflector and a solar cell with a plane mirror exposed to air as a cooling medium is experimentally measured, and its performance with and without the mirror are contrasted. The efficacy of solar PV cells with plane mirrors and solar PV cells with plane mirrors exposed to air as a cooling medium was evaluated by experimental observation.

ACKNOWLEDGEMENT

First, I would like to express my sincere gratitude to my supervisors, Associate Professor Rajesh Kaji Kayastha for proper guidance, valuable ideas and suggestions throughout the research period and encouragement to do this thesis work. I would also like to thank Dr. Surya Prasad Adhikari, Head, Department of Mechanical and Aerospace Engineering and all the faculty members for their suggestions to accomplish my task. I would like to express my sincere gratitude and thanks to Associate Professor Nawaraj Bhattarai, program coordinator, MSESPM for creating an excellent interactive atmosphere for thesis work.

I would like to thank Department of Hydrology and Meteorology for providing irradiance data. I would like to express my special thanks to My Hostel colleague for providing necessary help in my research work.

Lastly, I would also like to thank my friends of MSESPM for their help and support during the research period.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

K.E	Kinetic Energy
W	Watt
A	Ampere
V	Volt
I	Current
F	Frequency of light
PV	Photo Voltaic
R	Resistance
V_{AB}	Voltage across circuit points A and B
a1	Area of cell-cell gap
A	Area of panel
T	Thickness of cell-cell gap
Pav.	Average power produced without mirror
Pav.w	Average power produced with mirror
I	Intensity of light
P_i	Percentage increment of initial power
$P_i$av.	Average percentage increment of initial power
TW	Tera watt THz
Case 1	Solar PV cells without plane mirror
Case 2	Solar PV cells with plane mirror
Case 3	Solar PV cells with plane mirror subjected to air as a cooling medium

CHAPTER ONE: INTRODUCTION

1.1 Background

The potential of solar energy to supply our everyday needs is enormous. One of the finest sources of environmentally friendly, cost-effective renewable energy is the solar power system. Solar power is a free, abundant, and environmentally benign resource that can be used practically all year long and is present everywhere on Earth.

Nuclear energy and the limited supply of oil are the main sources of power production in developing nations, ecology and atmosphere are polluted by these resources. Because of this, scientists scour around the world looking for cheap, renewable energy sources. Unlike traditional energy sources, which are mostly found in a small number of nations, renewable energy resources are spread throughout a large geographic region. Solar cells are the most effective renewable energy sources for the direct conversion of solar light into electricity, which enables them to provide electricity at minimal cost. Photovoltaic technology has recently taken on a significant position among alternative renewable energy sources, and research into these technologies is now continuing to grow. Organic semiconductor-based solar cell devices are appealing due to their light weight, mechanical flexibility, clean solar energy conversion, low cost of manufacture, and potential for mass production (Biber *et al.*, 2017).

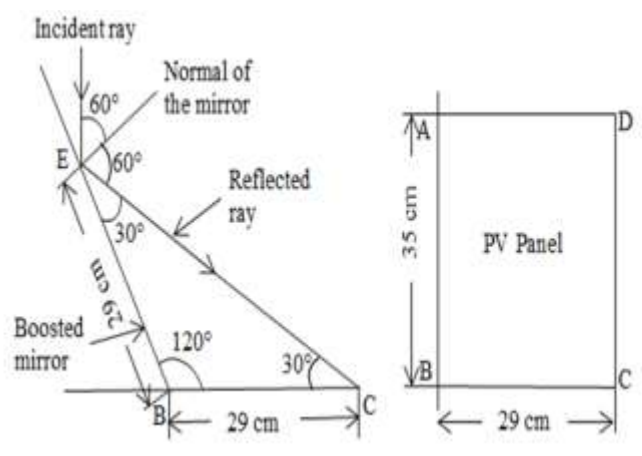

Figure 1 Reflection of light to PV [https://www.pveducation.org/pvcdrom/properties-of-sunlight]

One easy way to improve the performance of PV system is to use cost effective reflecting mirrors and light concentrators like concentrator photovoltaic (CPV). Conventional manufacturing techniques provide low-cost production due to the little cost and straightforward assembly of reflecting mirrors. A PV cell of this generation is claimed to have a theoretical efficiency close to 25% to 30% and a practical efficiency close to 17%. The system's efficiency may be raised to a higher level by cooling the panel with air or water. Figure above depicts how solar panels in Nepal are inclined relative to the path of the sun.

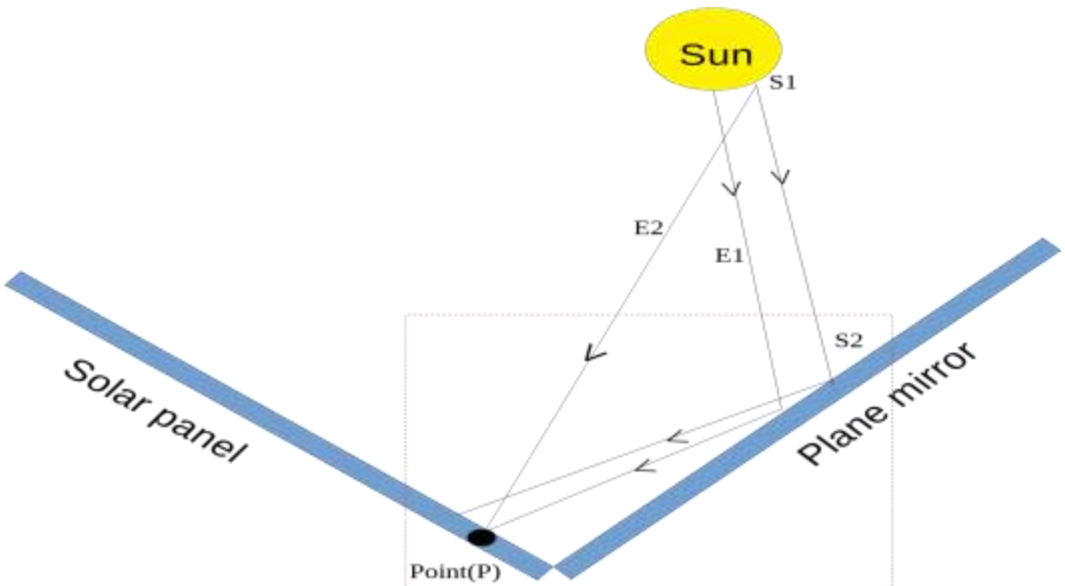

Figure 2 Theoretical setup to increase efficiency of PV cell

Sunlight based photovoltaic (PV) frameworks are a quickly extending supportable sustainable power source showcase, and will assume a vast part later on economic vitality blend (Pearce, 2019), (Pearce, 2011). At present, commercial and utility scale PV establishments are predominately organized in various parallel columns of level modules, which are aligned towards the mean maximum solar intensity (Deline *et al.*, 2013). Solar cells are made from semiconducting materials such as silicon (Si), the second most abundant material in the world after oxygen, which is used to convert the sunlight's photons into electrons.

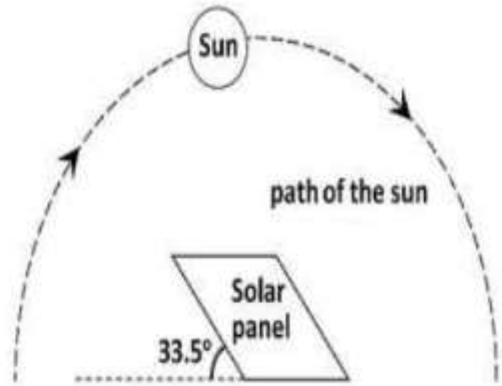

Figure 3 path of sun radiation w.r.t. PV cell
[https://livingonsolarpower.wordpress.com/category/sun/]

Energy is the central requirement for humankind today. It guarantees better personal satisfaction. For every day, utilizing continuous Energy has turned into a need for mankind now a days. As energy is like blood to power the economy of any nation so without it economy will tremble and it will be difficult to manage it. Everywhere throughout the world, Energy is one of the main issues what's more, every nation is searching for Energy assets as its request is expanding forcefully. Non-sustainable power source assets are either excessively costly or harming the earth and furthermore, they are in the end going stage and they do not have distant future. That is the reason the world is moving towards sustainable power source assets which are normally recharged in a moderately little time-frame (Is, 2010). Even if hydroelectricity is a very insignificant sustainable energy source, it isn't available everywhere on the earth, but solar energy has the potential to take over control of the whole energy era. The sun has been providing energy in two structures for hundreds of years: light and warmth. Today, sunlight based Energy is utilized to deliver power by utilizing photovoltaic cells (Gla, 1968).

Solar photovoltaic systems and technology are becoming a promising choice for power age. The amount of solar power output is about 166 PW out of which 85 PW reaches the Earth. This shows not only that solar power is well over 500 times our current world 15 TW power consumption, but also that all other sources are less than 1% of solar power output (Mendoza, 2005) . The radiation, which is not reflected or scattered and reaches the surface directly is called 'direct or beam radiation and the scattered radiation reaching the ground is called diffuse radiation (Mousazadeh *et al.*, 2009). Basically, the role of concentration photovoltaic systems is to collect both beam and scattered irradiation, which do not reach the photovoltaic cells.

1.2 Problem Statement

The research problem is to investigate way of increasing efficiency of solar PV panel. The ordinary efficiency of the solar PV panel was in between 15% to 20 % hence it was better idea to do some experimental research regarding enhancement of efficiency of the solar PV panel. Lower power production from solar PV cells in freshly installed solar street lamps, small solar power plants, and large solar power plants as a result of dust buildup, shadowing, and cloudy weather. Relatively significant dust deposition on the solar panels may be seen as a result of the high dust content in the atmosphere in many polluted regions. The streets should be illuminated by solar technology for roughly 10 to 12 hours each day. Solar technology should be used to brighten the streets for about 10 to 12 hours every day. Because of a variety of reasons, controlling the power for an LED bulb for that long may not always be achievable. For those solar devices to run consistently and flawlessly for the appropriate period of time, the system's batteries must be charged to their maximum capacity. Numerous variables affect how batteries charge, but the main one that controls charging is the quantity of irradiance. In situations like shade and dust buildup, even an adequate quantity of irradiance is occasionally inadequate to charge the batteries. For the modern energy market, solar energy was essential, but solar PV panel efficiency needed to be increased.

As a result, a series of experimental data were collected for analytical purposes based on three cases in accordance with the general theory of solar PV cells. The purpose of using a plane mirror as a reflector was to take use of the double radiation, which includes diffused radiation reflected from the mirror and direct beam radiation from the sun by solar PV cells. Short circuit current and open circuit voltage will be measured in each of the three scenarios that is power output of solar PV panels without a plane mirror, power output of solar PV panels with a plane mirror, and power output of solar PV panels with a plane mirror exposed to air as a cooling medium. This research is focused to increase the efficiency of the solar PV cells by using plane mirror and air as a cooling medium when optimum temperature of PV panel cross the optimum temperature range.

1.3 Justification

This study begins with the goal of comprehending or discovering the true effect of a plane mirror on solar PV cells in order to boost efficiency. The Asian Development Bank and the Nepalese government have invested heavily on solar street lighting, the efficiency of which must be evaluated. This study is being conducted to determine the effect of a plane reflector on PV cells in order to increase the efficiency of solar panels. It is anticipated that the results of this research will contribute to the accurate estimation of power requirements on streets and other locations where the efficiency of solar PV cells is low due to adverse weather conditions such as shading, clouding, and so on.

A similar technology PV panel from various manufacturers suffers in a completely different way. For a typical PV user, it is critical to understand how frequently the panel must be efficient. If achieving optimal efficiency is not possible, it is critical to understand the performance loss caused by unfavorable weather in order to make extra estimates to compensate for the loss. The study on effect of plane mirror on the PV panel will help to select panel technology for particular type of application and location.

1.4 Assumptions and Limitations

- The Pulchowk area in the Kathmandu valley is the sole area of the study. Other areas of Kathmandu may also experience varying weather conditions.
- The effect of increasing power production is only estimated as a function of a few weather factors; other meteorological variables are not taken into account due to their immediate unavailability.
- Although wind direction and speed may have been crucial variables in this study, their absence from DHM restricted it to examining the effects of the variables that were present.
- In order to get greater precision, weather stations must be put next to experimental setup. The absence of that in this research's scenario may not indicate a precise effect.

- Only one location was used in the research, and both primary and secondary data were collected. The increase in sample size may cause the outcome for Nepal as a whole to vary.

1.5 Objective of Study

1.5.1 Main Objective

i. To find out the performances of solar PV cell when solar PV cells, External plane mirror and cooling medium are used in different configurations.

1.5.2 Specific Objective

i. To find out the change in efficiency of solar PV panel when solar PV cell was subjected to plane mirror and cooling medium in different configurations.

ii. To find out intensity of light which was utilized by solar PV cell to generate electricity when solar PV cells, External plane mirror and cooling medium are used in different configurations.

iii. To compare the power output of solar PV cell vs. different time of radiation in each day when solar PV cells, external plane mirror and cooling medium are used in different configurations.

1.6 Scope of Work

Renewable energy is fast gaining relevance as an energy supply as fossil fuel costs vary and they are the main polluters of the environment. At the educational level, it is consequently vital for engineering students to grasp and appreciate the technology involved with renewable energy. One of the most popular renewable energy sources is the solar energy. Many researches were conducted to develop some methods to increase the efficiency of the solar photovoltaic system. The efficiency of solar PV panel was lower i.e. in between 15 percent to 20 percent hence is essential to do work in the improvement of solar PV cells. One such method is to employ a plane mirror to track more amount of radiation in different operating condition and environmental condition. Using different ways to track the solar energy system to follow the sun can increase solar energy input based on this type of tracker. By utilizing plane mirror as a reflector, we can increase the power output of PV cells which can optimize the total cost per unit production of power.

CHAPTER TWO: LITERATURE REVIEW

2.1 General Introduction on PV Cells

Photovoltaic power was first discovered by a French scientist Antoinc Becquerel in 1839. Charles Frits created the first functional solar cell in 1882. It was constructed of thin sheets of selenium that had been gold-plated. Although the use of solar panels to create energy and heat appears to be a recent discovery, it has been routinely employed to generate power since the early 1900s. The first crystal silicon solar cell was mass manufactured in 1954 by Bell Laboratories. The bell PV cell produced 4% of the sun's energy into electricity, which was considered cutting-edge in energy technology at the time. Scientists proceeded to rethink and improve on the initial silicon cell design, eventually producing a solar cell with a 20% return power rate. Scientists continued to develop the silicon PV in the late 1900s as awareness rose in the scientific community about the consequences of global warming and the need for renewable energy sources, and by early 2000 they were able to produce a solar cell with a 24% electricity return. Scientists were able to double the power return of a silicon solar cell utilizing space age elements in just seven years. By 2007, modern silicon PV solar cells were operating with 25% electricity return.

2.2 Solar Energy and Photovoltaic Cell

Sunlight based energy is a clean, eco-benevolent and plentiful asset accessible wherever on earth and all year. It has evaluated that in only 60 minutes, the sun powered energy got by the earth surpasses the energy utilization of the world's prerequisite for entire year.

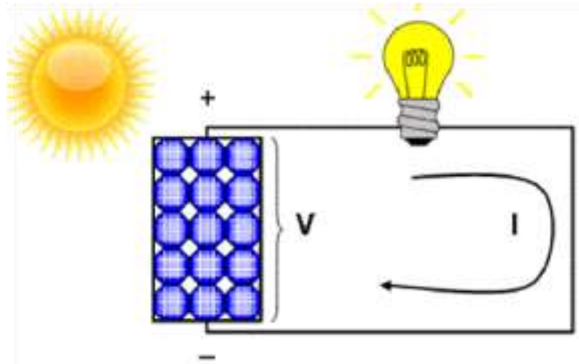

Figure 4 solar energy uses by PV cell [https://energyeducation.ca/encyclopedia/Photovoltaic_cell]

The capacity of sunlight-based energy to mitigate natural change is also notable. Sun-powered energy has the advantage of creating minimal ozone-harming compounds, and it is thus required to substitute a large amount of petroleum derivatives. A little amount of CO_2 is released during the manufacturing of changing devices. Sunlight has a wide range of applications, including lighting, heating, distillation, and the production of fuels. When exposed to sunlight, a photovoltaic cell may create direct current (DC). In a closed circuit, DC voltage can induce DC current to flow. A single solar cell generates a DC voltage of 0.5 volts (Dhankhar, Pal Singh and Singh, 2014). A group of PV cells forms a PV module.

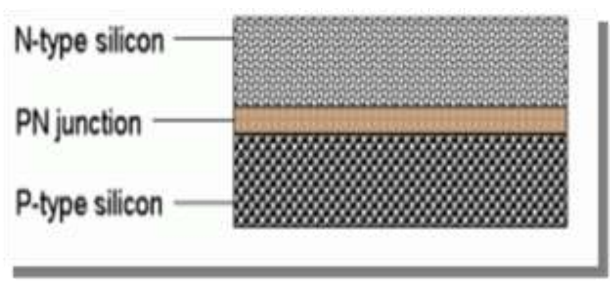

Figure 5 PV cell structure [https://www.hindawi.com/journals/tswj/2013/470347/]

The cells of a PV module can be linked in series or parallel and are enclosed in an environmentally protecting laminate. PV modules are the fundamental building blocks of PV solar systems. Modules can be linked together to provide the required power output configuration. For example, 36 solar cells put together in a PV module produce enough electricity to charge batteries and power tiny motors. Photovoltaic panels are constructed using semiconductor material.

The difference between conductors, insulators and semiconductors:

- Conductors — contain freely moving electrons
- Insulators — do not contain freely moving electrons
- Semiconductors — can have freely moving electrons under certain conditions.

Semiconductors are placed between conductors and insulators. This means that, depending on the circumstances, semiconductors may serve as either a conductor or an insulator. Sunlight is the critical circumstance that causes the PV module's semiconductor material to function as a conductor. Sunlight feeds electrons with energy, causing an electric current to flow. A typical representative of semiconductor is silicon (Paranthaman, Wong-Ng and Bhattacharya, 2015). Silicon is widely used in solar panels production since it can be easily produced from sand. Silicon, in general, functions like an insulator and contains no freely moving electrons. In its original condition, silicon is useless for making PV generating units since there are no free electrons accessible, hence no current can flow. Silicon is doped with boron and phosphorous to produce freely flowing electrons, which are characteristic of conductors. A solar cell consists of a P-type and N-type of silicon combined together. The N-type silicon forms the side of the cell that faces the sun, while the P-type silicon is the side facing away from the sun (Fraas and Partain, 2010). At the boundary of between a P-type and N-type semiconductor a PN junction is formed. When a PN junction is exposed to sunlight, electric current starts flowing as a result of the photo-voltaic effect (Bube and Fahrenbruch, 1981).

2.3 Electricity Generation Form Solar PV

PV systems are made up of PV cells, which are devices that convert light energy into electricity. The word PV comes from “photo,” meaning light, and “voltaic,” which refers to producing electricity. As a result, the PV method "directly produces electricity from sunlight," and they are sometimes referred to as solar cells.

2.3.1 Working Principle:

PV cells convert sunlight directly into electricity because they are constructed of at least two layers of semiconductor, one positive and one negative. When light reaches the cell, some photons are absorbed by the semiconductor atoms, allowing electrons from the negative layer of the cell to flow via an external circuit and back into the positive layer. This is known as the photoelectric effect, and the movement of electrons generates electric current. Hundreds of individual PV cells are joined in a sealed, weatherproof box called a module to improve their effectiveness. Modules are linked in series and parallel to build a PV array to obtain the necessary voltage and current.

2.3.2 Components of Radiation

Solar radiation incident on the atmosphere from the direction of the sun is the solar beam radiation. This radiation passing through the earth's atmosphere is attenuated, or reduced, by about 30%. Beneath the atmosphere, at the Earth's surface, the radiations that will be observable are beam radiations and diffuse radiations.

2.3.3 Beam Radiation

The solar radiation received from the sun without having been scattered by the atmosphere.

2.3.4 Diffuse Radiation

The solar radiation received from the sun after its direction has been changed by scattering by the atmosphere.

As a result, Total Solar Radiation is the sum of the beam and diffuse solar radiation on a surface. Figure 6 depicts the many components of solar radiation.

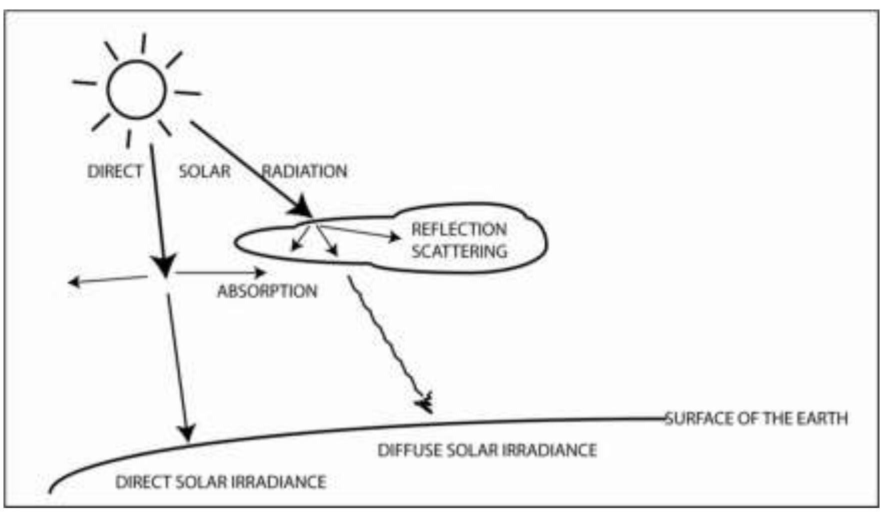

Figure 6 Components of solar radiation [http://elad.su-per-b.org/images/e/ec]

Annual average daily global solar radiation for Kathmandu and found it to be 3.83 kWh/m2/day; the maximum and minimum global solar radiation of 5.33 and 2.08

kWh/m2/day is recorded in April and September 2010 respectively; the seasonal variation of solar energy is about 2.87 kWh/m2/day and 4.83 kWh/m2/day in summer and spring respectively which is not in line with the general trend. The coefficient of correlation (R) between cloud transmittance factor and clearness factor is found to be 0.97.

2.4 The Laws of Reflection

A light ray is a stream of light having the lowest cross-sectional area achievable. The incident ray is a ray that is approaching a surface. The incident ray strikes a surface at the point of incidence. The normal is a perpendicular to the surface construction line drawn at the point of incidence.

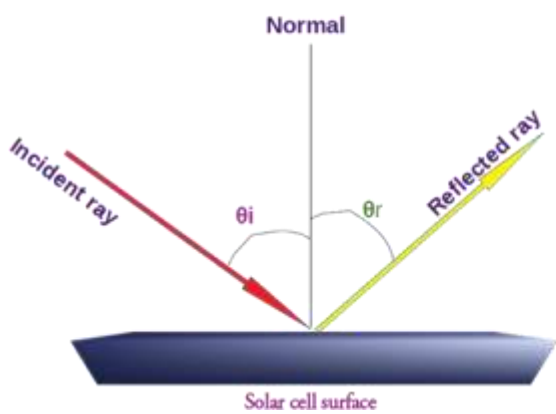

Figure 7 Reflection of sunlight [https://www.pngwing.com/en/free-png-sfowg]

The part of the incident ray that leaves the surface at the point of incidence is known as the reflected ray. The angle of incidence is defined as the angle formed between the incident ray and the normal. The angle of reflection is defined as the angle formed by the normal and reflected rays. The incidence angle equals the reflection angle. The incident ray, normal ray, and reflected ray are all coplanar.

When incoming parallel rays are reflected parallel on a smooth surface, this is referred to as specular reflection. When parallel incident rays are reflected, they are no longer parallel if the surface is rough on a microscopic level. As a result, diffuse reflection occurs. Diffuse reflection follows the rules of reflection. The irregular surface may be thought of as a collection of several tiny flat reflecting surfaces arranged at slightly varied angles (Julajaturasirarath, Jonburom and Pornsuwancharoen, 2012).

2.5 Solar Modules

A solar module consists of solar cells connected together and encapsulated against various climatic conditions. The purpose of connecting solar cells is to increase voltage, current, and power production. The maximum number of cells in a solar module is restricted by the size and weight of the module. Solar cells can be linked in either series or parallel. Cells coupled in series generate more voltage, but cells connected in parallel generate more current. The most typical structure of a conventional solar module is seen below. A junction box is positioned on the rear of each PV module to allow correct wiring to connect to other modules. Certainly, PV modules should be installed in such a way that water does not enter the junction boxes. Solar cells in a solar module are often linked in series to create a greater voltage. PV modules should be light and compact enough to be put on rooftops, even in severe weather. Solar modules are joined in series to get even greater voltage.

2.6 Capturing Lost Energy

The majority of technical efforts to reduce solar power prices focus on raising the efficiency of solar PV cells, which improves the number of watts generated by a particular panel under normal test conditions. This is generally a beneficial thing, but the benefit is reduced by high tariffs that increase the cost of solar panels. Using mirrors to shine more sun on the panels can significantly crank up their output. The mirrors are placed opposite the solar panels to send more light toward the modules in front of them. The light that hits them is reflected back toward the solar panels to produce more electricity (DOE, 2001).

The improvement in efficiency production of solar energy system will make big difference in the use of solar panels (Mitchell, Nagrial and Rizk, 2006). A flat panel solar module is a practical way in which common households and business can produce electrical or mechanical energy from solar energy conversion. The solar energy is still more expensive then the classical fossil burned electricity (Rizk and Nagrial, 2009).

2.7 Plane Mirror

A plane mirror is a mirror having a flat reflective surface. When light beams strike a planar mirror, the point of reflection is measured up to the edge of incidence. The edge of rate is the edge between the episode beam and an imaginary line perpendicular to the surface. In this way, the edge of reflection is the edge between the reflected beam and the typical and a collimated light emission does not spread out after reflection from a plane mirror, with the exception of diffraction effects (Mitchell, Rizk and Nagrial, 2006). A plane mirror is created by using a highly reflective and clean surface, such as silver or aluminum, in a process known as silvering. After silvering, a tiny layer of red lead oxide is applied to the back of the mirror. The reflecting surface reflects the vast majority of the light striking it as long as the surface a remaining parts uncontaminated by discoloring or oxidation. The mirrors (Bilal *et al.*, 2016).

2.8 Cooling of Solar PV Panel

To reduce the operating temperature of solar cells, experts developed cooling devices, which may be classified as active or passive. While passive cooling does not require the use of additional power, active cooling systems use mechanical or electrical equipment such as fans or pumps that do. Passive cooling may require additional components, such as a heat pipe or heat sink that uses convective heat transfer to force coolant flow to the solar cells. The area of heat transfer from a solar cell to its surrounding environment will be expanded by adding a heat sink made of thermally conductive material to the bottom of the solar cell. As a result, heat sinks should be enhanced further since they have a high potential as PV panel cooling devices and are very simple and inexpensive to manufacture.

The open-circuit voltage is directly impacted by the increased circuit resistance brought on by the PV cell's surface temperature, which also negatively affects the cell's material. The increased circuit resistance also restricts the electron's velocity. The electron's velocity is also limited by the increasing circuit resistance. The temperature coefficient, also known as the voltage drop-in/temperature-rise unit, indicates the strong dependency of PV power output on the surface temperature of the PV and explains the temperature sensitivity of the specific material utilized for PV cell performance studies. PV module manufacturers frequently include the value of T in their sales brochures.

The current study, which cites a large number of research articles, provides a detailed overview of the different cooling approaches utilized to keep module operating temperatures closer to the prescribed limit in order to optimize PV module performance. Passive cooling techniques and active cooling procedures are the two main types of cooling strategies.

The lifespan of semiconductor material may be impacted by a straightforward heat sink, according to Zhu and Sun's modeling and simulations of heat sinks. Based on the numerous research being done on heat sink applications for PV solar cells, it is quite possible to combine modeling and experimental methodologies to create an integrated study (Momirlan and Veziroglu, 2005). The development of PV cooling systems will be aided by this research strategy, which offers a complete theoretical and analytical assessment of the methods for reducing solar cell temperature.

2.9 Short Circuit and Open Circuit

When there is no voltage flowing through the circuit's components, the circuit is said to be shorted. According to Ohm's law, a short circuit for a resistive element also suggests that there is either no resistance or very little resistance.

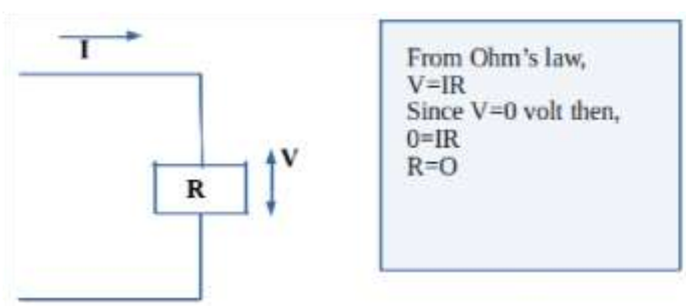

Figure 8 short circuit diagram

A circuit is open when there is no current flows through the circuit elements .For Resistive element, open circuit is also implies by ohm's law that there is infinite or very large resistance.

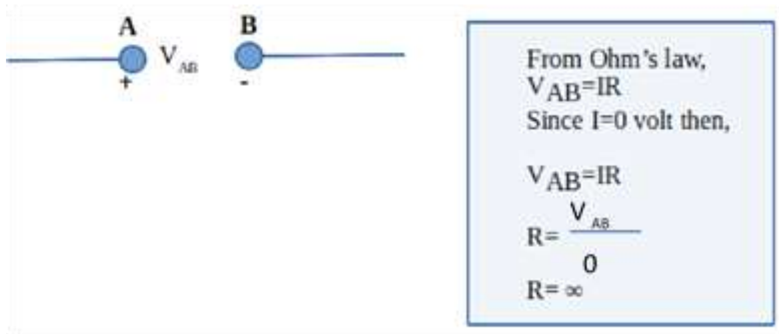

Figure 9 Open Circuit

2.10 Previous Research and Findings

i. Aliyu Abubakar & M.H Ali, Of Nigeria did the study on PV cell with plane mirror in 2017 and found that the presence of plane reflector increased the performance of solar cells. They found that, with presence of plane mirror, the fluctuation in power produced by solar cell can be made in balance by using plane mirror as a reflector (Abubakar and Ali, 2017).

ii. Muhammad Bilal, Muhammad Naeem, Muhammad Zain, Abideen Afridi did the study on solar cells with plane mirror in Pakistan in 2017 and found that there is Increasing in the Output Power and Efficiency of Solar Panel by Using Concentrator Photovoltaic (CPV) (Bilal *et al.*, 2016).

iii. Ignacio Luque and Carlos Martin studied the system that had a sub-degree precision tracker and a set of micro-concentrator PV modules. It was built using lightweight structures conferring it a significant resistance to high wind speeds. The system collected 95% of the total available direct solar radiation (Luque-heredia *et al.*, 2003).

iv. Decrease in cell efficiency due to overheating was tackled in Popovici, Hudişteanu, Mateescu and Cherecheş (Popovici *et al.*, 2016) work by the use of air cooled heat sink method. While the use of the water cooling was recommended for the improvement of efficiency by Odeh and Behnia (Taylor, 2011).

v. Abd-Elhady, Fouad and Khalil (2016) reported increase of 20% in the cell efficiency by smearing oil on the surface of the panel to increase the amount of light transmitted to the panel (Abd-elhady, Fouad and Khalil, 2016).

vi. Gordon JM, Wenger HJ studied Hourly computer simulation models of the field layout, the tracker array and geometry sensitivity for PV based central station. The analysis of both the ground cover ratio (GCR) and the effect of the maximum rotation angle on yearly energy losses in fixed and tracking models showed that the shading losses increase with GCR for each system (Gordon and Wenger, 1991).

vii. Popovici et al, simulated the properties of heat transport in a heat sink under turbulent flow conditions using the ANSYS-Fluent program. The findings demonstrated that a solar cell's cooling rate was related to the height of its fins and inversely proportional to the arrangement of the inclination angle. The solar cell's temperature was lowered to 10°C while its electrical power output was boosted to 7.55 percent (Popovici *et al.*, 2016).

viii. Using an experimental approach, (Alamri *et al.*, 2021) research's demonstrated a number of heat sinks with flared fin shapes attained a total decrease in thermal resistance of up to 10%.

ix. (Arifin *et al.*, 2020) did study on the aluminum fins attached to a PV panel's backside (Si-poly, 50 WP), The findings demonstrated that solar cells electrical efficiency rises by 0.3 percent and 0.2 percent under sun irradiation of 850 W/m2 and 500 W/m2, respectively, in low wind circumstances.

CHAPTER THREE: METHODOLOGY

3.1 Site Assessment

In the introduction of solar photovoltaic (PV) cell for private, commercial, or agricultural operations; a crucial idea was determined for the merits of the site. Identifying the place and position of the panels was a crucial step in designing a PV system as the later components have been streamlined to this step. A few concepts and tips had kept in mind while performing the site assessment are:

a. Shade Analysis
b. Sun hours
c. Panel tilt angle

3.2 Construction of Proposed PV Module with Plane Mirror

The Mirror reflected solar panel was constructed using locally available raw materials to make it cost effective. At first the plane mirror was made attached to the solar panel with optimum angle. A frame was constructed to support the reflectors made to the sizes in appropriate standard. The reflector was mounted on the frame that can rotate in a horizontal as well as in a vertical axis.

3.3 Working Procedure

To run the experiment, the whole system was to be put under sunlight. At first, the open circuit voltage and short circuit current have to be measured as a data of tracking with reflection system. After that the mirror was closed by a cover of opaque material and data was taken as only tracking system. The mirror cover was again open and data were taken as tracking with plane reflection mirror, then the PV panel is subjected to air cooling medium and output voltage and current are to be measured.

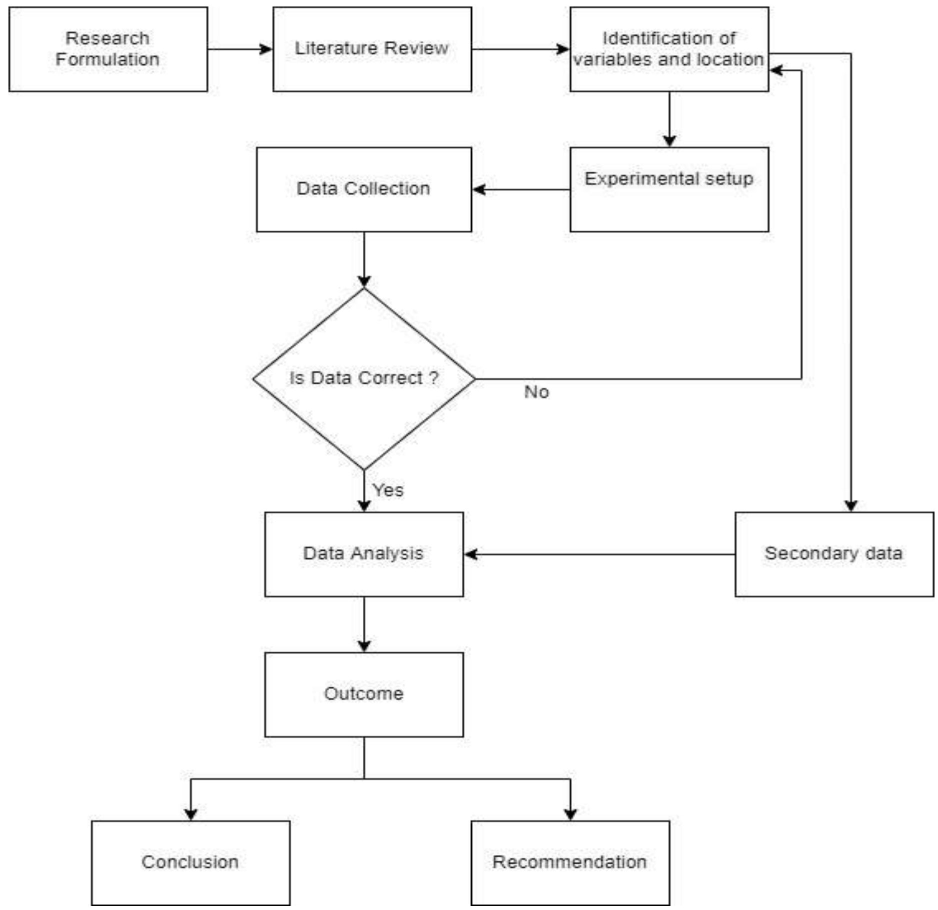

Figure 10 Data calculation and analysis flow chart

Considering the geometry and position of sun and proposed site, a PV module was kept inclined at 30 degree to horizontal axis. Solar panel will be positioned to the north southern direction. The reflecting mirrors had to attach to the edges of the solar panel. The mirror was aligned in such a ways that maximum amount of sun radiation will be reflected over the solar panel. If size of the reflecting mirror is identical to the size of the solar panel then experiments show that it must be inclined at 120 degree to get the maximum output of the panel, but if, the size of the mirror is twice the size of the solar panel then there is no need of exact 120 degree inclination.

3.4 Data Collection

The experiments were conducted for a total of 15 days and the data were collected. Among them, data taken on fifteen days have been presented in Table as representative. The table have shown the open circuit (OC) voltage and close circuit (CC) current for various mode as: tracking only and tracking with reflection and tracking with reflection subjected to air as a cooling medium.

3.5 Calculation of Data

The data obtained from the experiments on each day was calculated for various parameters like power from tracking system (PTS), power from tracking with reflection system (PTRS) and power from tracking with reflection subjected to air as a cooling medium. Then a comparison had been made between PTS, PTRS and PTRS with cooling medium.

3.6 Graphical Representation of Data

The power was calculated for each experimental days and the data collected on experimental days. for various modes as mentioned earlier were plotted as power versus time of the day. Among them the graphs for each day was presented.

3.7 Solar PV Cell without Reflecting Plane Mirror

The information were seen by the similar investigation of intensity yields of sunlight based PV board, which can be acquired by utilizing with and without external plane mirror (utilized as concentrator). The 20 watt MS Solar panel was used for this experiment. First of all, the arrangement had been made and short circuit current and open circuit voltage of solar panel was measured to calculate power output. In first case, data were taken when there is no plane mirror and cooling medium i.e. only power output of solar PV cells of normal conditions. The accompanying supplies can be utilized amid the procedure of information perception:

Figure 11 Experimental setup for data taking procedure for case 1

•Sun based PV cell is the essential gear for the experiment.

• Multimeter is utilized to get information precisely.

3.8 Solar PV Cell with Reflecting Plane Mirror

The generation of electricity from solar energy varies morning to evening in a day, contingent upon the intensity of light. More power can be extracted at noon when the intensity of light is at its pinnacle. As electricity produced by PV module is directly related to the intensity of light radiation it is receiving, so in order to increase the performance of the system a concentrating technique may be a better solution. This would extensively decrease the cost of generation of electricity by PV panels. So a plane mirror was subjected to solar PV cells at appropriate angle and short circuit current and open circuit voltage were measured to calculate power output of solar PV cells with plane mirror.

PV panel and plane mirror were utilized for getting better power output.

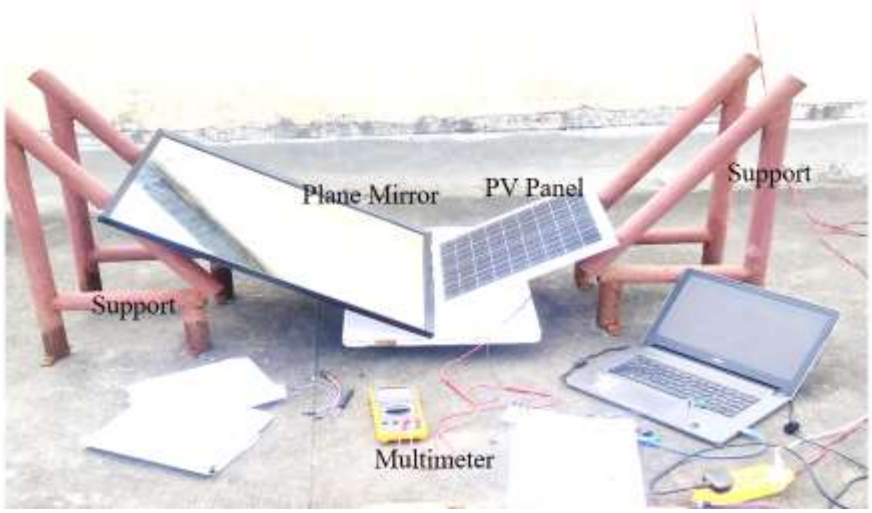

Figure 12 Experimental setup for data taking procedure for case 2

Plane mirror was used for reflection of sunlight over the PV panel.

Data were acquired by utilizing digital multimeter.

3.9 Solar PV Cell with Reflecting Plane Mirror Subjected to Air as Cooling Medium

Depending on the brightness of the sun throughout the day, different amounts of electricity are produced from solar energy from morning to evening. When the light is at its strongest at noon, more power may be drawn. A focusing approach could be a better option to improve system performance because the amount of power a PV module produces is directly connected to the amount of light radiation it is receiving. This would significantly lower the price of producing power using solar panels. Whenever there was a high intensity of light then temperature of PV cells crossed the optimum temperature level so in order to keep the temperature of PV cells with in limit, air was subjected as a cooling medium which was supplied by air cooling fan.

PV panel was utilized for power output.

Figure 13 Experimental setup for data taking procedure for case 3

Plane mirror was used for reflection of sunlight over the PV panel and cooling fan was used for supplying air for cooling solar PV cells. Data were acquired by utilizing digital multimeter.

The experimental data were taken in fifteen different days in between Jun 22, 2022 to August 5, 2022 at rooftop of MSC hostel, Pulchowk campus - Lalitpur, Nepal. The coordinate was 27.67° N, 85.316°E. The plane mirror of area (l=55cm×58.5cm= 3217.5 cm^2) as the concentrator was used. The main idea was that the intensity of light increases due to the use of mirror. The data was obtained by using multimeter as shown in the image taken during the project. Two stands are used in the image to fix the panel at same angle and coordinate. The data were taken using digital multimeter.

The currents and voltages were recorded with respect to time and multiplied for power calculation. There were three condition with and without mirror and called conditional powers. The data recorded were plotted for line graphs with the help of Microsoft office. The graph were colored for clear vision and understanding.

CHAPTER FOUR: RESULT AND DISCUSSION

4.1 Calculation Area

For this project, a solar panel of MS solar company was used whose power output was 20 watts. PV panel have a inner length 31.4 cm and breadth was 36.3 cm. The solar panel consists of 90 small cells called solar cells, each solar cell of length 3.9 cm and breadth 2.9 cm. All cells were connected in series such that current gets increases. Solar cell were manufactured by basic element silicon whose work function is 4.8 eV.

For intensity of light falling to the panel. Generally, the intensity of light was calculated as the power per unit area of panel. But, it was observed that, there were small gaps in the panel which can be a major factor for the accuracy of intensity.

Now, taking only the solar cell covered area for greater accuracy calculation. For this purpose, It was measured that area of panel ($A=31.4\ cm\times36.3\ cm= 1139.82\ cm^2$) and area of each solar cell ($a = 3.9cm\times2.9\ cm=11.31\ cm^2$). For 90 solar cell, the total area was ($90\times11.31\ cm^2 =1017.9\ cm^2$). In addition, there were white gaps between cells. The gaps were cell-cell gap and column-column gap.

It measure cell-cell gap length was exactly equal to the solar cell length and the column-column length was equal to the inner length of solar panel. So, It calculate the area of first cell-cell gap ($a1=8 \times 31.6cm \times0.30\ cm = 75.84\ cm^2$). Now, the area of column-column gap was calculated as ($36.5cm\times0.44cm\times3 = 48.18\ cm^2$).

Figure 14 Solar panel used for experiment

Calculation:

Area of panel = 1139.82 cm².

Area of 90 solar cells = 1017.9 cm².

Area of column-column gap = 48.18cm².

Area of cell-cell gap = 75.84 cm².

Area of panel = Area of 90 solar cells + Area of cell-cell gap +Area of column-column gap-doubling portion

= (1017.9+48.18+75.84-2.1) cm².

= 1017.9 cm².

4.2 Plane Mirror

The plane mirror of area (l=55cm×58.5cm= 3217.5 cm²) as the concentrator was used. The mirror was inclined at 30 degree with horizontal surface.

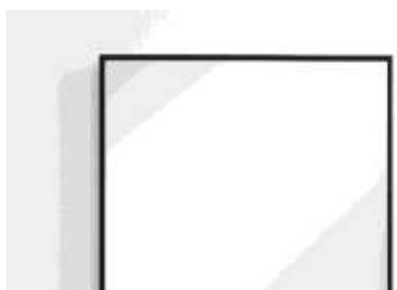

Figure 15 Plane mirror used in experiment

Plane mirror was used as a reflector of sun radiation towards solar PV cells in case two and case three.

4.3 Air Cooling Medium

For the cooling purpose of solar PV cells, cooling fan was used. The fan was used in arrangement of solar cells with plane mirror for making case three.

Figure 16 Cooling fan used in experiment

The fan was rotated at speed of 2000 RPM. The fan have three blade and approximately 2 kg weight. AC source was used for running fan. During experiment the maximum temperature of solar PV cells raises up to 37 degree centigrade and fan was able to decrease solar cells temperature to 27 degree centigrade at peak temperature. Fan reduce the temperature of solar PV cells by 8 to 10 degree on average when running at full speed.

Table 1 Data collection of voltage, current and power in Day 1

Time (S)	Case 1 - without mirror and without fan			Case 2 - with mirror and without fan			Case 3 - with mirror and with fan		
	Voltage (V)	**Current (A)**	**Power (W)**	**Voltage (V)**	**Current (A)**	**Power (W)**	**Voltage (V)**	**Current (A)**	**Power (W)**
10:15 AM	20.5	1.03	21.12	20.9	1.05	21.95	20.91	1.05	21.96
11:00 AM	17.26	0.78	13.46	20.6	0.95	19.57	20.62	0.95	19.59
11:30 AM	16.88	0.65	10.97	18.89	0.81	15.30	18.91	0.88	16.64
12:15 PM	16.95	0.66	11.19	18.4	0.7	12.88	18.6	0.76	14.14
12:45 PM	18.7	1.1	20.57	20.9	1.14	23.83	21.21	1.21	25.66
1:00 PM	19.1	0.88	16.81	19.8	0.91	18.02	19.98	0.93	18.58
1:30 PM	20.7	1.12	23.18	21.2	1.19	25.23	21.4	1.21	25.89
2:00 PM	20.1	1.08	21.71	20.92	1.17	24.48	20.99	1.2	25.19
2:30 PM	19.85	0.95	18.86	20.1	1.11	22.31	20.28	1.24	25.15
3:00 PM	19.09	0.87	16.61	19.9	0.91	18.11	19.94	0.92	18.34
3:30 PM	18.5	0.99	18.32	19.1	1.05	20.06	19.23	1.1	21.15
4:00 PM	18	0.92	16.56	18.56	0.99	18.37	18.58	0.99	18.39
5:00 PM	17.4	0.83	14.44	17.51	0.86	15.06	17.52	0.86	15.07

The graph was plotted by using the data observed in day 1, showed that the power of solar panel increases or decreases with respect to time, temperature and intensity of light. These data affected after [11:00AM] by seasonal clouds. The light gets intense after the mid-day. So, at [12:15 PM] the power recorded 11.19 watts without using plane mirror, when using plane mirror, the output power of solar panel increased to 12.88 watts and when air cooling medium was subjected to PV panel with mirror then power was recorded to 14.14 watts. At [1:30PM] the power without mirror is 23.18 watts and power gets increased by using mirror to 25.23 watts and in case 3 the power was increased to 25.89 watts. Similarly, it showed that, as time increases the conditional powers decreases due to low intensity of light. At [1:00 PM] both conditional powers decreases due to low intensity light couldn't reach the panel because of seasonal clouds, as a result temperature of panel decreases. The graph between [1:30PM] to [2:30PM] was nearly constant for with and without mirror. The conditional power at [3:30PM] with mirror and fan was 21.15 watts, with mirror was 20.06 watts and with only PV panel up-to 21.15 watts and decreases slowly.

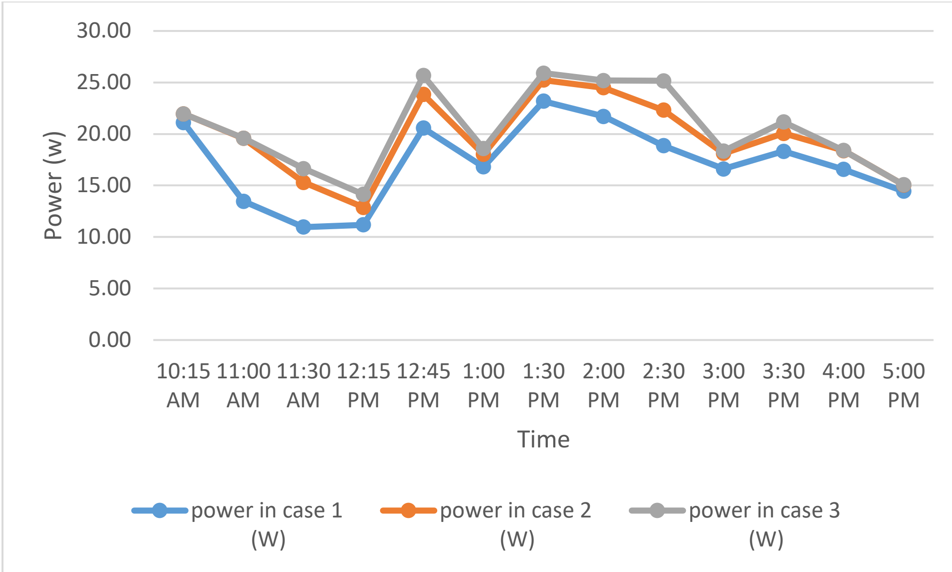

Figure 17 Power output of solar PV cells vs. different time of radiation in day 1

Average power produced in case 1 = $\frac{223.79}{13}$= 17.21 watts.

Average power produced in case 2 = $\frac{255.15}{13}$ = 19.63 watts.

Average power produced in case 3 = $\frac{265.76}{13}$ = 20.44 watts.

Table 2 Efficiency calculation in each case with data of day 1

Average power differences in case 1 & case 2	2.41 watts
Average power differences in case 1 & case 3	3.23 watts
Average power differences in case 2 & case 3	0.82 watts
% increment in efficiency of PV by using mirror	14.01%
% increment in efficiency of PV by using mirror & cooling medium	18.75%
% increment in efficiency of PV by using cooling medium in case 2	4.16%

It was found that, the power produced with using mirror gets increased up to 14.01% by utilization of plane mirror as concentrator and the power produced with using mirror gets increased up-to 18.75% by utilization of plane mirror as a concentrator and air as a cooling medium. The efficiency of air cooling to the arrangement of PV panel with plane mirror was found to be 4.16% in day 1.

Table 3 Data collection of voltage, current and power in Day 2

	Case 1 - without mirror and without fan			Case 2 - with mirror and without fan			Case 3 - with mirror and with fan		
Time (S)	Voltage (V)	Current (A)	Power (W)	Voltage (V)	Current (A)	Power (W)	Voltage (V)	Current (A)	Power (W)
10:00 AM	17.21	0.79	13.60	17.8	0.84	14.95	17.81	0.84	14.96
10:45 AM	18.3	0.91	16.65	18.9	0.94	17.77	19.1	0.95	18.15
11:15 AM	19.8	0.94	18.61	20.1	0.99	19.90	20.5	1.01	20.71
12:05 PM	21.3	1.06	22.58	21.41	1.14	24.41	21.63	1.19	25.74
12:20 PM	21.8	1.01	22.02	21.95	1.16	25.46	22.09	1.17	25.85
12:45 PM	20.8	1.04	21.63	21.23	1.08	22.93	21.39	1.11	23.74
1:00 PM	21.01	1.12	23.53	21.23	1.19	25.26	21.31	1.22	26.00
1:15 PM	21.54	1.13	24.34	21.81	1.18	25.74	22.01	1.21	26.63
1:45 PM	20.8	1.03	21.42	21.07	1.21	25.49	21.1	1.25	26.38
2:30 PM	20.5	0.99	20.30	20.91	1.13	23.63	20.99	1.17	24.56
3:15 PM	20.41	0.97	19.80	20.89	1.19	24.86	20.9	1.2	25.08
4:00 PM	19.5	0.95	18.53	19.82	0.98	19.42	19.83	0.99	19.63
5:00 PM	18.3	0.83	15.19	18.41	0.91	16.75	18.41	0.91	16.75

In day 2, the graph of conditional powers with respect to the time was plotted in accordance with the data obtained. These data were partly affected by seasonal clouds. The intense light gives 22.58 watts power without mirror, 24.41 watts power with mirror and with mirror subjected to air as a cooling medium gives 25.74 watts power at the mid-day i.e. at [12:05PM]. The graph fluctuated up and down due to the temperature of solar cells, change in intensity of light, seasonal clouds.

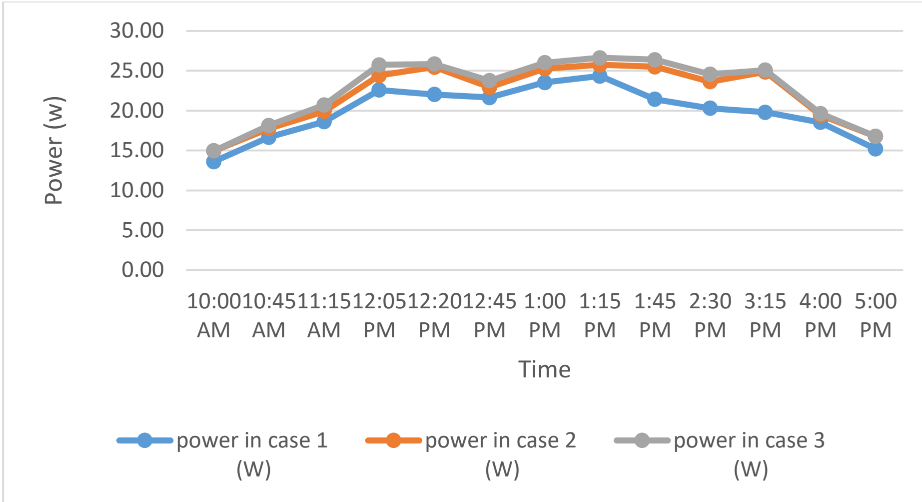

Figure 18 Power output of solar PV cells vs. different time of radiation in day 2

Average power produced in case 1 = $\frac{258.19}{13}$ = 19.86 watts.

Average power produced in case 2 = $\frac{286.57}{13}$ = 22.04 watts.

Average power produced in case 3 = $\frac{294.17}{13}$ = 22.63 watts.

Table 4 Efficiency calculation in each case with data of day 2

Average power differences in case 1 & case 2	2.18 watts
Average power differences in case 1 & case 3	2.77 watts
Average power differences in case 2 & case 3	0.58 watts
% increment in efficiency of PV by using mirror	10.99%
% increment in efficiency of PV by using mirror & cooling medium	13.93%
% increment in efficiency of PV by using cooling medium in case 2	2.65%

The maximum power of solar cell without mirror was 22.58 watts at [12:05PM], with mirror was 25.74 watts and mirror with cooling medium was 26.63 watts at [1:15PM]. The minimum power of solar cell without mirror was 13.60 watts and with mirror 14.95 watts and with mirror and cooling medium was 14.96 watts at [10:00AM].

It was found that, the power produced with using mirror gets increased up-to 10.99% by utilization of plane mirror as concentrator and the power produced with using mirror gets increased up-to 13.93% by utilization of plane mirror as a concentrator and air as a cooling medium. The efficiency of air cooling to the arrangement of PV panel with plane mirror was found to be 2.65% in day 2.

Table 5 Data collection of voltage, current and power in Day 3

Time (S)	Case 1 - without mirror and without fan			Case 2 - with mirror and without fan			Case 3 - with mirror and with fan		
	Voltage (V)	Current (A)	Power (W)	Voltage (V)	Current (A)	Power (W)	Voltage (V)	Current (A)	Power (W)
10:15 AM	19.1	0.87	16.62	19.7	0.93	18.32	19.7	0.93	18.32
10:45 AM	20.3	1.11	22.53	20.67	1.23	25.42	20.69	1.24	25.66
11:30 AM	18.4	0.8	14.72	18.71	0.83	15.53	18.71	0.83	15.53
12:00 PM	20.1	1.11	22.31	20.71	1.19	24.64	21.08	1.23	25.93
12:30 PM	21.1	1.19	25.11	21.23	1.21	25.69	21.4	1.24	26.54
1:00 PM	19.3	0.94	18.14	19.81	0.98	19.41	19.87	0.99	19.67
2:00 PM	20.2	1.08	21.82	20.61	1.19	24.53	20.65	1.22	25.19
2:30 PM	20.83	1.14	23.75	20.88	1.21	25.26	20.91	1.26	26.35
3:00 PM	19.1	0.99	18.91	19.7	1.02	20.09	20.1	1.11	22.31
3:30 PM	18.3	0.79	14.46	18.71	0.82	15.34	18.73	0.84	15.73
4:00 PM	17.2	0.83	14.28	17.37	0.9	15.63	17.38	0.93	16.16
4:30 PM	16.8	0.68	11.42	16.93	0.7	11.85	16.93	0.7	11.85
5:00 PM	16.4	0.65	10.66	16.49	0.67	11.05	16.49	0.67	11.05

The data recorded in day 3 were plotted above the table for conditional output powers of cells. These data partly affected by seasonal clouds. It showed that, the powers obtained from cells without mirror was 22.31 watts, with mirror was 24.64 watts and cells with mirror subjected to air as a cooling medium was 25.93 watts at [12:00AM]. The power were fluctuated up and down and gradually decreased with respect to time, intensity, and temperature of cells. The maximum and minimum power without using mirror were 25.11 watts at [12:30 PM] and 10.66 watts at [5:00 PM] respectively. The maximum and minimum power for cells with mirror were 25.69 watts at [12:30PM] and 11.05 watts at [5:00 PM] respectively. The maximum and minimum power for cells with mirror subjected to air as a cooling medium were 26.54 watts at [12:30PM] and 11.05 watts at [5:00 PM] respectively.

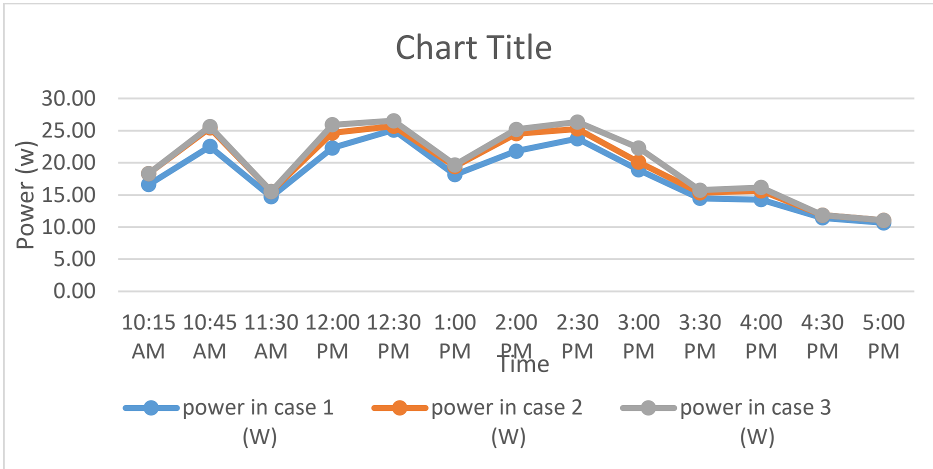

Figure 19 Power output of solar PV cells vs. different time of radiation in day 3

Average power produced in case 1 = $\frac{234.72}{13}$ = 18.06 watts.

Average power produced in case 2 = $\frac{252.78}{13}$ = 19.44 watts.

Average power produced in case 3 = $\frac{260.29}{13}$ = 20.02 watts.

Table 6 Efficiency calculation in each case with data of day 3

Average power differences in case 1 & case 2	1.39 watts
Average power differences in case 1 & case 3	1.97 watts
Average power differences in case 2 & case 3	0.58 watts
% increment in efficiency of PV by using mirror	7.69%
% increment in efficiency of PV by using mirror & cooling medium	10.89%
% increment in efficiency of PV by using cooling medium in case 2	2.97%

It was found that, the power produced with using mirror gets increased up to 7.69% by utilization of plane mirror as concentrator and the power produced with using mirror gets increased up-to 10.89% by utilization of plane mirror as a concentrator and air as a cooling medium. The efficiency of air cooling to the arrangement of PV panel with plane mirror was found to be 2.97% in day 3.

Table 7 Data collection of voltage, current and power in Day 4

	Case 1 - without mirror and without fan			Case 2 - with mirror and without fan			Case 3 - with mirror and with fan		
Time (S)	**Voltage (V)**	**Current (A)**	**Power (W)**	**Voltage (V)**	**Current (A)**	**Power (W)**	**Voltage (V)**	**Current (A)**	**Power (W)**
10:15 AM	16.71	0.64	10.69	16.92	0.69	11.67	16.92	0.69	11.67
10:45 AM	17.8	0.78	13.88	18.69	0.81	15.14	18.7	0.81	15.15
11:30 AM	20.3	1.01	20.50	21.09	1.09	22.99	21.3	1.1	23.43
12:00 PM	22.44	1.51	33.88	22.94	1.58	36.25	23.11	1.62	37.44
12:30 PM	23.21	1.68	38.99	23.38	1.81	42.32	23.47	1.93	45.30
1:00 PM	21.42	1.24	26.56	21.51	1.39	29.90	21.69	1.51	32.75
1:30 PM	22.31	1.41	31.46	22.42	1.49	33.41	22.71	1.63	37.02
2:00 PM	22.95	1.58	36.26	22.99	1.63	37.47	23.13	1.69	39.09
2:30 PM	21.87	1.28	27.99	22.1	1.48	32.71	22.19	1.53	33.95
3:00 PM	21.79	1.27	27.67	22.02	1.42	31.27	22.08	1.44	31.80
3:30 PM	20.59	1.11	22.85	20.72	1.21	25.07	20.74	1.23	25.51
4:00 PM	19.73	0.92	18.15	19.98	0.99	19.78	19.99	0.99	19.79
4:30 PM	17.35	0.78	13.53	17.72	0.82	14.53	17.72	0.82	14.53

In nearly one and half Hour before of mid-day to observe the nature of conditional powers of solar cells. The data were plotted and calculated as powers lines shown in below graph. Before mid-day [11:30AM] the power of solar cell without mirror was 20.5 watts, with mirror was 22.41 watts and power output of solar cell with mirror subjected to air as a cooling medium was 23.78 watts. The power with mirror line fluctuated frequently as compared to the power without line. The maximum power for solar cell with mirror line was 26.04 watts at [2:00PM], for without mirror was 25.26 watts at [3:00PM] and solar PV cells with plane mirror subjected to air as a cooling medium was 26.90 watts at [1:00PM]. The minimum power for solar cells with mirror was 14.53 watts at [10:15AM], solar cells without mirror line was 15.55 watts at [10:15 AM] and solar PV cells with plane mirror subjected to air as a cooling medium was15.55 watts at [10:15AM]. In day 4, the currents and voltages of solar PV cells were recorded for different time

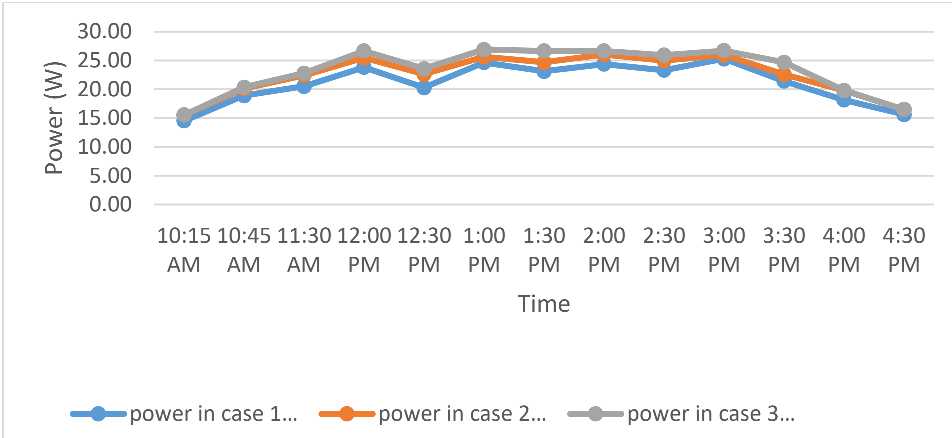

Figure 20 Power output of solar PV cells vs. different time of radiation in day 4

Average power produced in case 1 = $\frac{273.91}{13}$ = 21.07 watts.

Average power produced in case 2 = $\frac{292.20}{13}$ = 22.48 watts.

Average power produced in case 3 = $\frac{302.58}{13}$ = 23.28 watts.

Table 8 Efficiency calculation in each case with data of day 4

Average power differences in case 1 & case 2	1.41 watts
Average power differences in case 1 & case 3	2.21 watts
Average power differences in case 2 & case 3	0.80 watts
% increment in efficiency of PV by using mirror	6.68%
% increment in efficiency of PV by using mirror & cooling medium	10.47%
% increment in efficiency of PV by using cooling medium in case 2	3.55%

The high intense light falling on solar cells cause the temperature rise and as a result it affects the power line to fluctuate frequently while the less intense light falling on the cell surface couldn't increase such high temperature. Temperature of solar cell decreases the output power of solar cell.

It was found that, the power produced with using mirror gets increased up to 6.68% by utilization of plane mirror as concentrator and the power produced with using mirror gets increased up-to 10.47% by utilization of plane mirror as a concentrator and air as a cooling medium. The efficiency of air cooling to the arrangement of PV panel with plane mirror was found to be 3.55% in day 4.

Table 9 Data collection of voltage, current and power in Day 5

Time (S)	Case 1 - without mirror and without fan			Case 2 - with mirror and without fan			Case 3 - with mirror and with fan		
	Voltage (V)	Current (A)	Power (W)	Voltage (V)	Current (A)	Power (W)	Voltage (V)	Current (A)	Power (W)
10:30 AM	19.19	0.99	19.00	19.31	1.04	20.08	19.31	1.04	20.08
11:00 AM	18.54	0.94	17.43	18.62	0.96	17.88	18.63	0.97	18.07
11:30 AM	17.82	0.83	14.79	17.88	0.88	15.73	18.01	0.91	16.39
12:00 PM	19.34	0.98	18.95	19.77	1.05	20.76	19.85	1.11	22.03
12:30 PM	20.52	1.11	22.78	21.12	1.11	23.44	21.23	1.13	23.99
1:00 PM	21.31	1.12	23.87	21.37	1.16	24.79	21.44	1.16	24.87
1:30 PM	21.24	1.11	23.58	21.35	1.16	24.77	21.52	1.19	25.61
2:00 PM	21.43	1.14	24.43	21.51	1.17	25.17	21.62	1.19	25.73
2:30 PM	21.06	1.11	23.38	21.19	1.14	24.16	21.44	1.19	25.51
3:00 PM	20.53	1.01	20.74	20.79	1.11	23.08	20.92	1.13	23.64
3:30 PM	20.08	0.98	19.68	20.28	1.13	22.92	20.34	1.14	23.19
4:00 PM	19.21	0.93	17.87	19.41	0.99	19.22	19.42	0.99	19.23
4:30 PM	18.03	0.81	14.60	18.19	0.94	17.10	18.19	0.94	17.10

The graph was plotted by using the data observed in day 5, showed that the power of solar panel increases or decreases with respect to time, temperature and intensity of light. These data affected after [11:00AM] by seasonal clouds. The light gets intense after the mid-day. So, at [12:00 PM] the power recorded 18.95 watts without using plane mirror, when using plane mirror then the output power of solar panel increased to 20.76 watts and when air cooling medium was subjected to PV panel with mirror then power was recorded to 22.03 watts. At [1:30PM] the power without mirror is 23.58 watts and power gets increased by using mirror to 24.77 watts and in case 3 the power was increased to 25.61 watts. Similarly, it showed that, as time increases the conditional powers decreases due to low intensity of light. At [11:30 AM] both conditional powers decreases due to low intensity light couldn't reach the panel because of seasonal clouds, as a result temperature of panel decreases. The graph between [12:00PM] to [3:00PM] was nearly constant for with and without mirror. The conditional power at [3:30PM] with mirror and fan was 19.68 watts, with mirror was 22.92 watts and with only PV panel up to 23.19 watts and decreases slowly.

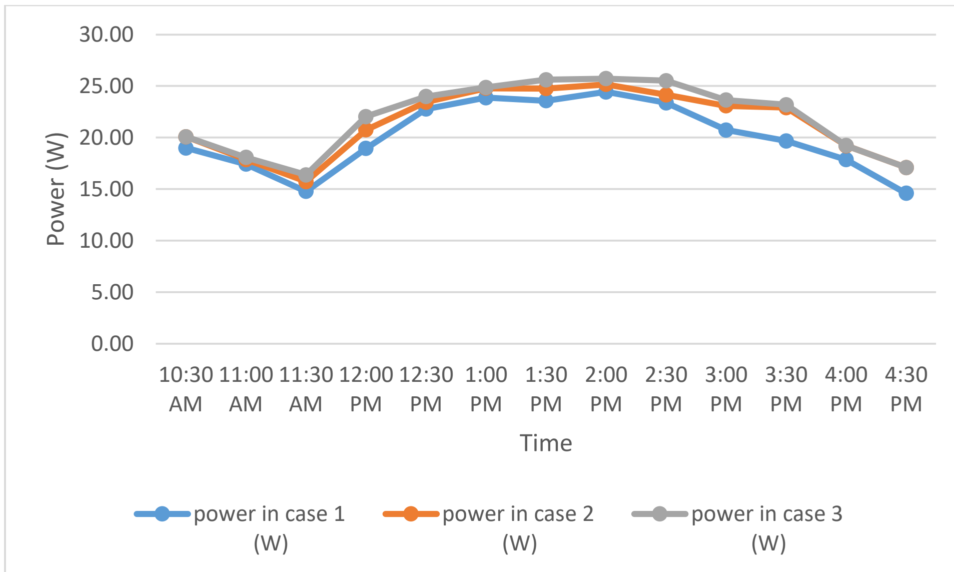

Figure 21 Power output of solar PV cells vs. different time of radiation in day 5

Average power produced in case 1 = $\frac{261.08}{13}$ = 20.08 watts.

Average power produced in case 2 = $\frac{279.08}{13}$ = 21.47 watts.

Average power produced in case 3 = $\frac{285.44}{13}$ = 21.96 watts.

Table 10 Efficiency calculation in each case with data of day 5

Average power differences in case 1 & case 2	1.38 watts
Average power differences in case 1 & case 3	1.87 watts
Average power differences in case 2 & case 3	0.49 watts
% increment in efficiency of PV by using mirror	6.89%
% increment in efficiency of PV by using mirror & cooling medium	9.33%
% increment in efficiency of PV by using cooling medium in case 2	2.28%

It was found that, the power produced with using mirror gets increased up to 6.89% by utilization of plane mirror as concentrator and the power produced with using mirror gets increased up to 9.33 % by utilization of plane mirror as a concentrator and air as a cooling medium. The efficiency of air cooling to the arrangement of PV panel with plane mirror was found to be 2.28% in day 5.

Table 11 Data collection of voltage, current and power in day 6

Time (S)	Case 1 - without mirror and without fan			Case 2 - with mirror and without fan			Case 3 - with mirror and with fan		
	Voltage (V)	Current (A)	Power (W)	Voltage (V)	Current (A)	Power (W)	Voltage (V)	Current (A)	Power (W)
11:15 AM	16.88	0.69	11.65	17.23	0.75	12.92	17.23	0.75	12.92
12:10 PM	21.3	1.02	21.73	21.6	1.08	23.33	21.75	1.08	23.49
12:25 PM	21.5	1.1	23.65	21.76	1.12	24.37	21.82	1.12	24.44
12:40 PM	21.7	1.08	23.44	21.81	1.11	24.21	22.01	1.12	24.65
12:55 PM	21.6	1.14	24.62	21.82	1.17	25.53	21.88	1.18	25.82
1:10 PM	21.7	1.11	24.09	22.2	1.13	25.09	22.32	1.19	26.56
1:25 PM	21.8	1.06	23.11	22.3	1.11	24.75	22.43	1.14	25.57
1:40 PM	20.1	0.96	19.30	20.6	1.02	21.01	20.72	1.07	22.17
1:55 PM	21.4	1.02	21.83	21.7	1.14	24.74	22	1.16	25.52
2:10 PM	20.6	0.97	19.98	21.1	1.01	21.31	21.19	1.11	23.52
2:25 PM	21.3	1.02	21.73	21.5	1.11	23.87	21.65	1.13	24.46
3:15 PM	20.5	0.94	19.27	20.9	1.03	21.53	21.01	1.03	21.64
4:05 PM	19.6	0.91	17.84	19.75	0.99	19.55	19.76	0.99	19.56

The data recorded above table in day 6 were plotted below for conditional output powers of cells. These data partly affected by seasonal clouds. It showed that, the powers obtained from cells without mirror was 23.44 watts, with mirror was 24.21 watts and cells with mirror subjected to air as a cooling medium was 24.65 watts at [12:40PM]. The power were fluctuated up and down and gradually decreased with respect to time, intensity, and temperature of cells. The maximum and minimum power without using mirror were 24.62 watts at [12:55 PM] and 11.65 watts at [10:15 AM] respectively. The maximum and minimum power for cells with mirror were 25.53 watts at [12:55PM] and 12.92 watts at [10:15 AM] respectively. The maximum and minimum power for cells with mirror subjected to air as a cooling medium were 26.56 watts at [1:10PM] and 12.92 watts at [10:15 AM] respectively.

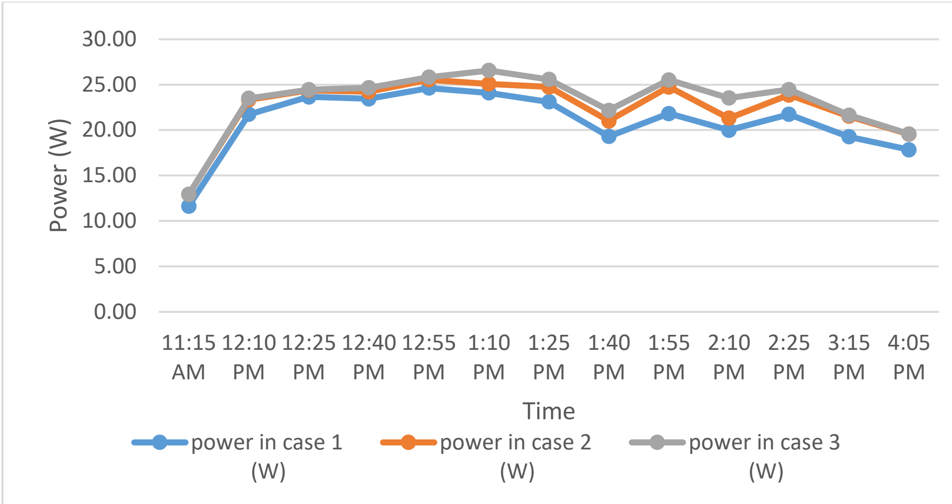

Figure 22 Power output of solar PV cells vs. different time of radiation in day 6

Average power produced in case 1 = $\frac{272.22}{13}$ = 20.94 watts

Average power produced in case 2 = $\frac{292.20}{13}$ = 22.48 watts

Average power produced in case 3 = $\frac{300.93}{13}$ = 23.10 watts

Table 12 Efficiency calculation in each case with data of day 6

Average power differences in case 1 & case 2	1.54 watts
Average power differences in case 1 & case 3	2.16 watts
Average power differences in case 2 & case 3	0.63 watts
% increment in efficiency of PV by using mirror	7.34%
% increment in efficiency of PV by using mirror & cooling medium	10.33%
% increment in efficiency of PV by using cooling medium in case 2	2.78%

It was found that, the power produced with using mirror gets increased up to 7.34% by utilization of plane mirror as concentrator and the power produced with mirror gets increased up to 10.33% by utilization of plane mirror as a concentrator and air as a cooling medium. The efficiency of air cooling to the arrangement of PV panel with plane mirror was found to be 2.78% in day 6.

Table 13 Data collection of voltage, current and power in Day 7

Time (S)	Case 1 - without mirror and without fan			Case 2 - with mirror and without fan			Case 3 - with mirror and with fan		
	Voltage (V)	Current (A)	Power (W)	Voltage (V)	Current (A)	Power (W)	Voltage (V)	Current (A)	Power (W)
10:15 AM	19.5	0.95	18.53	19.67	0.98	19.28	19.67	0.99	19.47
10:45 AM	20.5	1.01	20.71	20.71	1.08	22.37	20.72	1.1	22.79
11:30 AM	21.43	1.12	24.00	21.81	1.17	25.52	21.94	1.18	25.89
12:00 PM	21.21	1.11	23.54	21.51	1.16	24.95	21.72	1.19	25.85
12:30 PM	21.2	1.13	23.96	21.41	1.17	25.05	21.61	1.19	25.72
1:00 PM	20.8	1.03	21.42	21.3	1.11	23.64	21.45	1.17	25.10
1:30 PM	21.4	1.13	24.18	21.74	1.19	25.87	21.98	1.21	26.60
2:00 PM	21.5	1.13	24.30	21.8	1.17	25.51	22.03	1.2	26.44
2:30 PM	20.1	0.99	19.90	20.56	1.08	22.20	20.88	1.16	24.22
3:00 PM	19.92	0.94	18.72	20.21	1.05	21.22	20.32	1.11	22.56
3:30 PM	19.12	0.91	17.40	19.39	1.05	20.36	19.4	1.08	20.95
4:00 PM	18	0.92	16.56	18.56	0.99	18.37	18.57	0.99	18.38
5:00 PM	17.4	0.83	14.44	17.51	0.86	15.06	17.51	0.86	15.06

In day 7, the graph of conditional powers with respect to the time was plotted in accordance with the data obtained. These data were partly affected by seasonal clouds. The less intense light gives 23.54 watts power without mirror and 24.95 watts power with mirror and when solar cell with mirror was subjected to air as a cooling medium them power reached to 25.85 watts at [12:00PM]. The graph fluctuated up and down due to the temperature of solar cells, change in intensity of light, seasonal clouds.

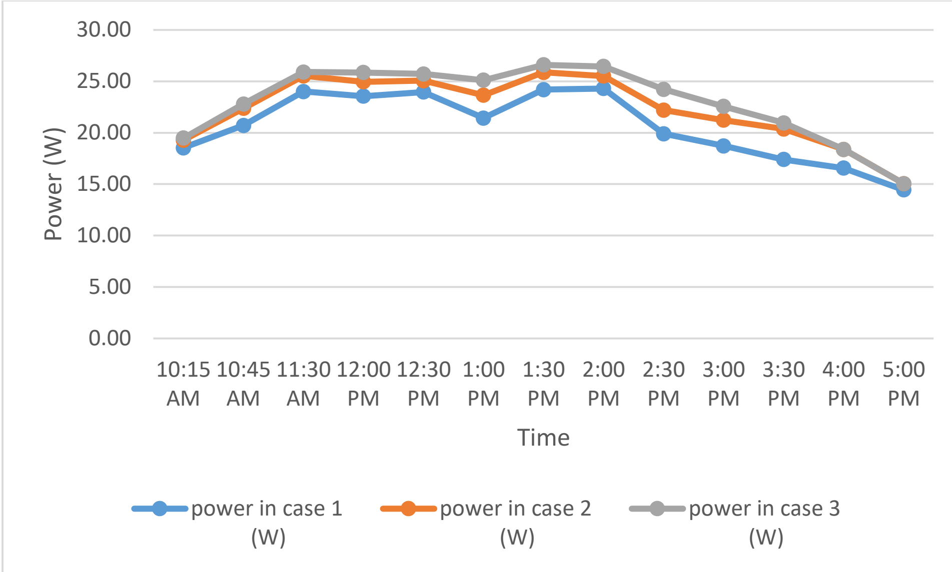

Figure 23 Power output of solar PV cells vs. different time of radiation in day 7

The maximum power of solar cell without mirror was 24.30 watts at [2:00PM], with mirror was 25.87 watts at [1:30PM] and mirror with cooling medium was 26.60watts at [1:30PM]. The minimum power of solar cell without mirror was 14.44 watts, solar cell with mirror was 15.06 watts and solar cell with mirror subjected to air as a cooling medium was 15.06 watts at time [5:00PM].

Average power produced in case 1 = $\frac{267.66}{13}$ = 20.59 watts

Average power produced in case 2 = $\frac{289.40}{13}$ = 22.26 watts

Average power produced in case 3 = $\frac{299.02}{13}$ = 23.01 watts

Table 14 Efficiency calculation in each case with data of day 7

Average power differences in case 1 & case 2	1.67 watts
Average power differences in case 1 & case 3	2.41 watts
Average power differences in case 2 & case 3	0.74 watts
% increment in efficiency of PV by using mirror	8.12%
% increment in efficiency of PV by using mirror & cooling medium	11.72%
% increment in efficiency of PV by using cooling medium in case 2	3.32%

It was found that, the power produced with using mirror gets increased up-to 8.12% by utilization of plane mirror as concentrator and the power produced with using mirror gets increased up-to 11.72% by utilization of plane mirror as a concentrator and air as a cooling medium. The efficiency of air cooling to the arrangement of PV panel with plane mirror was found to be 3.32% in day 7.

Table 15 Data collection of voltage, current and power in Day 8

	Case 1 - without mirror and without fan			**Case 2 - with mirror and without fan**			**Case 3 - with mirror and with fan**		
Time (S)	**Voltage (V)**	**Current (A)**	**Power (W)**	**Voltage (V)**	**Current (A)**	**Power (W)**	**Voltage (V)**	**Current (A)**	**Power (W)**
10:15 AM	18.6	0.91	16.93	18.78	1.01	18.97	18.78	1.01	18.97
11:00 AM	20.23	1.04	21.04	20.56	1.11	22.82	20.57	1.12	23.04
11:55 AM	21.2	1.14	24.17	21.5	1.17	25.16	21.82	1.19	25.97
12:10 PM	21.52	1.16	24.96	21.63	1.19	25.74	21.78	1.22	26.57
12:25 PM	20.8	1.04	21.63	20.99	1.11	23.30	21.1	1.13	23.84
1:40 PM	21.21	1.12	23.76	21.45	1.17	25.10	21.67	1.19	25.79
1:55 PM	21.34	1.14	24.33	21.46	1.18	25.32	21.76	1.21	26.33
2:10 PM	20.98	1.09	22.87	21.23	1.19	25.26	21.45	1.22	26.17
2:25 PM	21.23	1.13	23.99	21.52	1.17	25.18	21.82	1.23	26.84
2:40 PM	21.2	1.15	24.38	21.46	1.18	25.32	21.77	1.2	26.12
2:55 PM	21.4	1.16	24.82	21.57	1.18	25.45	21.91	1.19	26.07
3:10 PM	20.5	1.01	20.71	21.01	1.11	23.32	21.05	1.11	23.37
4:15 PM	19.04	0.99	18.85	19.12	1.02	19.50	19.12	1.02	19.50

The data recorded in day 8 were plotted in above table for conditional output powers of cells. These data partly affected by seasonal clouds. It showed that, the powers obtained from cells without mirror was 21.04 watts, with mirror was 22.82 watts and cells with mirror subjected to air as a cooling medium was 23.04 watts at [11:00AM]. The power were fluctuated up and down and gradually decreased with respect to time, intensity, and temperature of cells. The maximum and minimum power without using mirror were 24.96 watts at [12:10 PM] and 16.93watts at [10:15 AM] respectively. The maximum and minimum power for cells with mirror were 25.74 watts at [12:10PM] and 18.97 watts at [10:15 AM] respectively. The maximum and minimum power for cells with mirror subjected to air as a cooling medium were 26.84 watts at [2:25PM] and 18.97 watts at [10:15 AM] respectively.

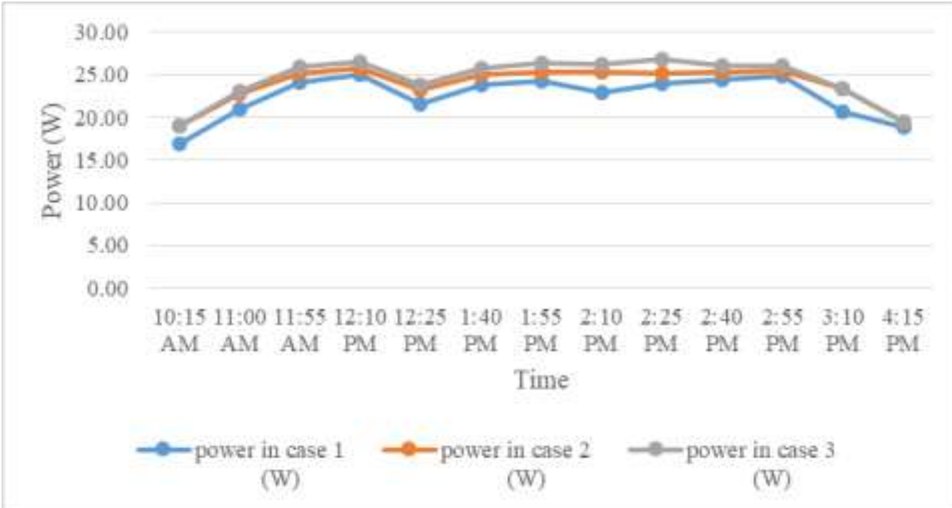

Figure 24 Power output of solar PV cells vs. different time of radiation in day 8

Average power produced in case 1 = $\frac{292.43}{13}$ = 22.49 watts.

Average power produced in case 2 = $\frac{310.44}{13}$ = 23.88 watts.

Average power produced in case 3 = $\frac{318.58}{13}$ = 24.51 watts.

Table 16 Efficiency calculation in each case with data of day 8

Average power differences in case 1 & case 2	1.39 watts
Average power differences in case 1 & case 3	2.01 watts
Average power differences in case 2 & case 3	0.63 watts
% increment in efficiency of PV by using mirror	6.16 %
% increment in efficiency of PV by using mirror & cooling medium	8.94 %
% increment in efficiency of PV by using cooling medium in case 2	2.62 %

It was found that, the power produced with using mirror gets increased up-to 6.16% by utilization of plane mirror as concentrator and the power produced with using mirror gets increased up-to 8.94% by utilization of plane mirror as a concentrator and air as a cooling medium. The efficiency of air cooling to the arrangement of PV panel with plane mirror was found to be 2.62% in day 8.

Table 17 Data collection of voltage, current and power in Day 9

Time (S)	Case 1 - without mirror and without fan			Case 2 - with mirror and without fan			Case 3 - with mirror and with fan		
	Voltage (V)	Current (A)	Power (W)	Voltage (V)	Current (A)	Power (W)	Voltage (V)	Current (A)	Power (W)
10:31 AM	16.2	0.71	11.50	17.1	0.81	13.85	17.1	0.81	13.85
11:00 AM	19.3	0.88	16.98	20.2	0.99	20.00	20.21	1	20.21
11:30 AM	21.3	1.11	23.64	21.46	1.13	24.25	21.56	1.14	24.58
12:00 PM	21.14	1.02	21.56	21.4	1.11	23.75	21.76	1.17	25.46
12:30 PM	21.46	1.13	24.25	21.78	1.18	25.70	21.99	1.21	26.61
1:00 PM	20.1	0.97	19.50	20.65	0.99	20.44	20.89	1.12	23.40
1:30 PM	21.5	1.12	24.08	21.91	1.17	25.63	22.04	1.21	26.67
2:00 PM	19.1	0.93	17.76	19.89	1.06	21.08	20.03	1.11	22.23
2:30 PM	20.9	1.09	22.78	21.4	1.14	24.40	21.52	1.18	25.39
3:00 PM	18.3	0.88	16.10	19.12	0.99	18.93	19.42	1.1	21.36
3:30 PM	19.12	0.87	16.63	19.67	0.99	19.47	19.72	1.02	20.11
4:00 PM	17.3	0.82	14.19	17.43	0.92	16.04	17.44	0.92	16.04
4:30 PM	16.4	0.73	11.97	16.92	0.78	13.20	16.92	0.78	13.20

In day 9, the current and voltage of solar PV cells were recorded for different time interval nearly one and half hour before of mid-day to observe the nature of conditional powers of solar cells. The data were plotted and calculated as powers lines shown in below graph. Before mid-day i.e. at [11:00AM] the power of solar cell without mirror was 16.98 watts, with mirror was 20.00 watts and power output of solar cell with mirror subjected to air as a cooling medium was 250.21 watts. The power with mirror line fluctuated frequently as compared to the power without line. The maximum power for solar cell with mirror was 25.70 watts [12:30PM], for solar cell without mirror was 24.25 watts [12:30PM] and solar cells with plane mirror subjected to air as a cooling medium was 26.67 watts at [1:30PM]. The minimum power for solar cells with mirror was 13.85 watts at [10:15AM], solar cells without mirror line was 11.85 watts at [10:15AM] and solar cells with plane mirror subjected to air as a cooling medium was13.85 watts at [10:15AM].

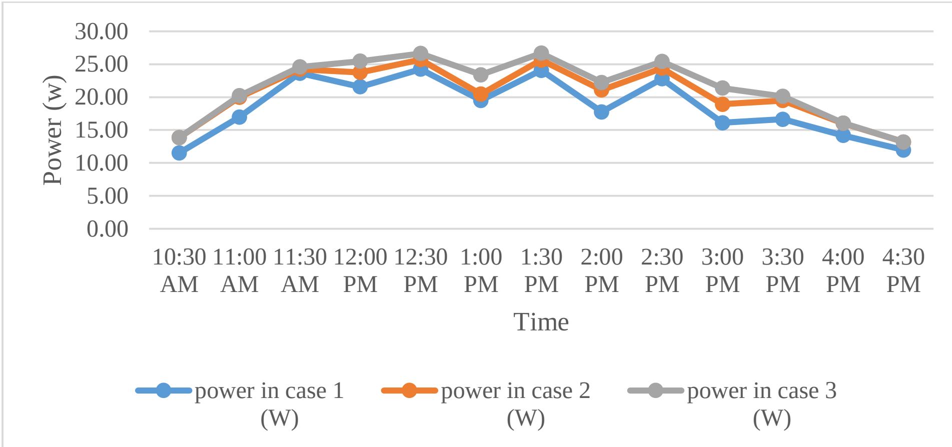

Figure 25 Power output of solar PV cells vs. different time of radiation in day 9

Average power produced in case 1 = $\frac{240.96}{13}$ = 18.54 watts.

Average power produced in case 2 = $\frac{266.75}{13}$ = 20.52 watts.

Average power produced in case 3 = $\frac{279.12}{13}$ = 21.47 watts.

Table 18 Efficiency calculation in each case with data of day 9

Average power differences in case 1 & case 2	1.98 watts
Average power differences in case 1 & case 3	2.94 watts
Average power differences in case 2 & case 3	0.95 watts
% increment in efficiency of PV by using mirror	10.70%
% increment in efficiency of PV by using mirror & cooling medium	15.84%
% increment in efficiency of PV by using cooling medium in case 2	4.64%

It was found that, the power produced with using mirror gets increased up to 10.70% by utilization of plane mirror as concentrator and the power produced with using mirror gets increased up-to 15.84% by utilization of plane mirror as a concentrator and air as a cooling medium. The efficiency of air cooling to the arrangement of PV panel with plane mirror was found to be 4.64% in day 9.

Table 19 Data collection of voltage, current and power in Day 10

Time (S)	Case 1 - without mirror and without fan			Case 2 - with mirror and without fan			Case 3 - with mirror and with fan		
	Voltage (V)	Current (A)	Power (W)	Voltage (V)	Current (A)	Power (W)	Voltage (V)	Current (A)	Power (W)
10:30 AM	14.9	0.36	5.36	15.3	0.41	6.27	15.3	0.41	6.27
11:00 AM	17.1	0.61	10.43	17.46	0.69	12.05	17.47	0.69	12.05
11:30 AM	20.08	0.91	18.27	21.04	0.99	20.83	21.6	1.07	23.11
12:00 PM	21.4	1.1	23.54	21.54	1.19	25.63	21.62	1.22	26.38
12:30 PM	21.1	1.07	22.58	21.24	1.11	23.58	21.31	1.17	24.93
1:00 PM	19.4	0.76	14.74	20.02	0.91	18.22	20.03	0.92	18.43
1:30 PM	19.2	0.73	14.02	19.82	0.81	16.05	19.82	0.82	16.25
2:00 PM	20.6	0.99	20.39	20.91	1.08	22.58	21.2	1.16	24.59
2:30 PM	20.9	1.04	21.74	21.11	1.14	24.07	21.18	1.19	25.20
3:00 PM	20.4	1.01	20.60	20.81	0.99	20.60	21.02	1.07	22.49
3:30 PM	18.5	0.74	13.69	18.92	0.94	17.78	18.94	0.95	17.99
4:00 PM	18.1	0.72	13.03	18.44	0.73	13.46	18.45	0.73	13.47
4:30 PM	16.2	0.52	8.42	16.33	0.57	9.31	16.33	0.57	9.31

The graph was plotted by using the data observed in day 10, showed that the power of solar panel increases or decreases with respect to time, temperature and intensity of light. These data affected after [12:30PM] by seasonal clouds. The light gets intense after the mid-day. So, at [1:00 PM] the power recorded 14.74 watts without using plane mirror, when using plane mirror, the output power of solar panel increased to 18.22 watts and when air cooling medium was subjected to PV panel with mirror then power was recorded to 18.43 watts. The power without mirror is 23.54 watts and power gets increased by using mirror to 25.63 watts and when air cooling medium was subjected to PV panel with mirror then power was recorded to 26.38 watts at [12:00PM]. Similarly, it showed that, as time increases the conditional powers decreases due to low intensity of light. At [1:00 PM] both conditional powers decreases due to low intensity light couldn't reach the panel because of seasonal clouds, as a result temperature of panel decreases. The graph between [11:30AM] to [12:30PM] and [2:00PM] to [3:00PM] was nearly constant for with and without mirror.

The conditional power at [3:30PM] with mirror and fan was 13.69 watts, with mirror was 17.78 watts and with only PV panel up to 17.99 watts and decreases slowly.

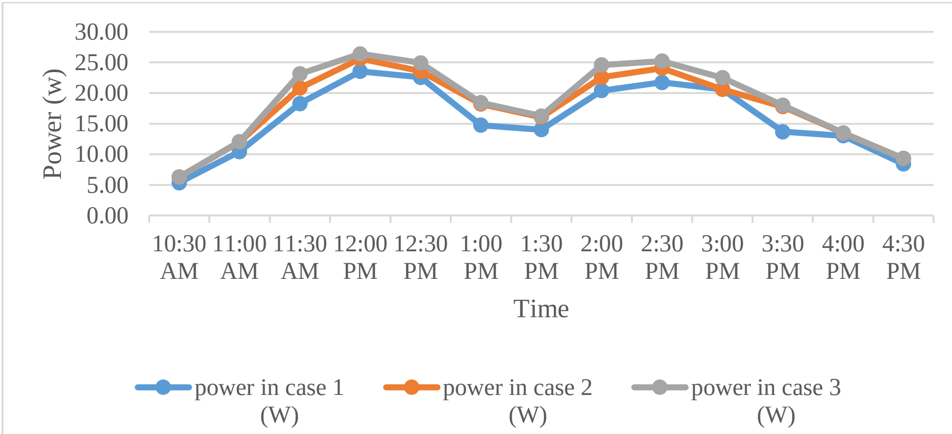

Figure 26 Power output of solar PV cells vs. different time of radiation in day 10

Average power produced in case 1 = $\frac{206.82}{13}$= 15.91 watts.

Average power produced in case 2 = $\frac{230.44}{13}$ = 17.73 watts.

Average power produced in case 3 = $\frac{240.49}{13}$ = 18.50 watts.

Table 20 Efficiency calculation in each case with data of day 10

Average power differences in case 1 & case 2	1.82 watts
Average power differences in case 1 & case 3	2.59 watts
Average power differences in case 2 & case 3	0.77 watts
% increment in efficiency of PV by using mirror	11.42%
% increment in efficiency of PV by using mirror & cooling medium	16.28%
% increment in efficiency of PV by using cooling medium in case 2	4.36%

It was found that, the power produced with using mirror gets increased up to 11.42% by utilization of plane mirror as concentrator and the power produced with using mirror gets increased up-to 16.28% by utilization of plane mirror as a concentrator and air as a cooling medium. The efficiency of air cooling to the arrangement of PV panel with plane mirror was found to be 4.36% in day 10.

Table 21 Data collection of voltage, current and power in Day 11

Time (S)	Case 1 - without mirror and without fan			Case 2 - with mirror and without fan			Case 3 - with mirror and with fan		
	Voltage (V)	Current (A)	Power (W)	Voltage (V)	Current (A)	Power (W)	Voltage (V)	Current (A)	Power (W)
10:30 AM	19.4	0.98	19.01	19.57	1.04	20.35	19.57	1.04	20.35
11:00 AM	19.81	1.04	20.60	20.14	1.09	21.95	20.15	1.09	21.96
11:30 AM	21.1	1.14	24.05	21.62	1.19	25.73	21.81	1.21	26.39
12:00 PM	21.24	1.19	25.28	21.69	1.21	26.24	21.98	1.22	26.82
12:30 PM	20.5	1.07	21.94	20.76	1.11	23.04	20.93	1.16	24.28
1:00 PM	20.78	1.14	23.69	21.07	1.19	25.07	21.44	1.2	25.73
1:30 PM	21.04	1.17	24.62	21.56	1.19	25.66	21.71	1.21	26.27
2:00 PM	17.5	0.81	14.18	17.84	0.88	15.70	17.85	0.89	15.89
2:30 PM	17.1	0.76	13.00	17.43	0.8	13.94	17.46	0.81	14.14
3:00 PM	19.89	0.99	19.69	20.31	1.1	22.34	20.62	1.14	23.51
3:30 PM	20.04	1.02	20.44	20.56	1.14	23.44	20.72	1.15	23.83
4:00 PM	16.56	0.69	11.43	16.89	0.74	12.50	16.91	0.74	12.51
4:30 PM	15.89	0.52	8.26	16.01	0.57	9.13	16.01	0.57	9.13

In day 11, the graph of conditional powers with respect to the time was plotted in accordance with the data obtained. These data were partly affected by seasonal clouds. The intense light gives 20.60 watts power without mirror, 21.95 watts power with mirror and with mirror subjected to air as a cooling medium gives 21.96 watts power at the mid-day i.e. at [11:00AM]. The graph fluctuated up and down due to the temperature of solar cells, change in intensity of light, seasonal clouds.

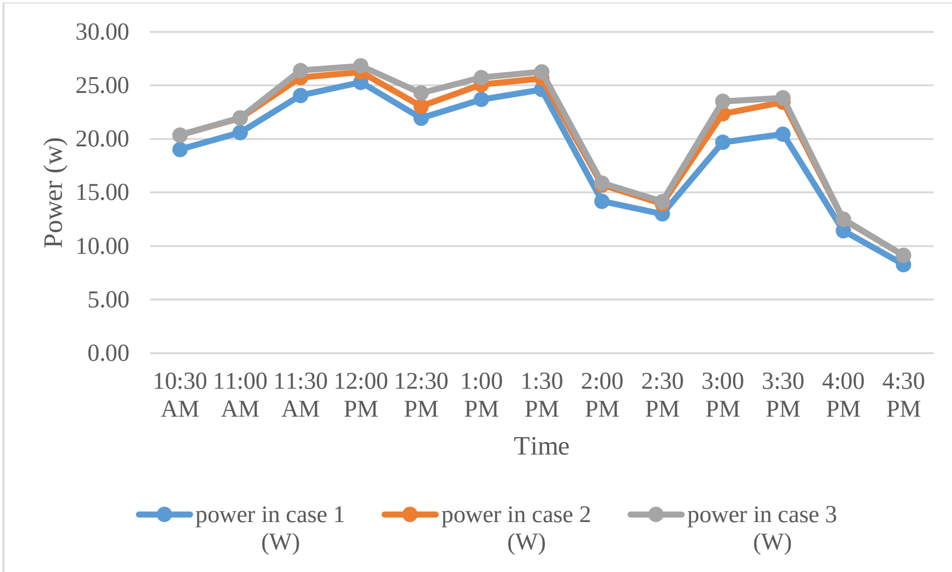

Figure 27 Power output of solar PV cells vs. different time of radiation in day 11

The maximum power of solar cell without mirror was 25.28 watts at [12:00PM], with mirror was 26.24 watts and power of solar cell with mirror when air was subjected as a cooling medium was 26.82 watts at [12:00PM]. The minimum power of solar cell without mirror was 8.26 watts and power of solar cell with mirror was 9.13 watts and power of solar cell with mirror when air was subjected as a cooling medium was 9.13 at [4:30PM].

Average power produced in case 1 = $\frac{246.18}{13}$ = 18.94 watts.

Average power produced in case 2 = $\frac{265.10}{13}$ = 20.39 watts.

Average power produced in case 3 = $\frac{270.80}{13}$ = 20.83 watts.

Table 22 Efficiency calculation in each case with data of day 11

Average power differences in case 1 & case 2	1.46 watts
Average power differences in case 1 & case 3	1.89 watts
Average power differences in case 2 & case 3	0.44 watts
% increment in efficiency of PV by using mirror	7.69%
% increment in efficiency of PV by using mirror & cooling medium	10%
% increment in efficiency of PV by using cooling medium in case 2	2.15%

It was found that, the power produced with using mirror gets increased up to 7.69% by utilization of plane mirror as concentrator and the power produced with using mirror gets increased up-to 10% by utilization of plane mirror as a concentrator and air as a cooling medium. The efficiency of air cooling to the arrangement of PV panel with plane mirror was found to be 2.15% in day 11.

Table 23 Data collection of voltage, current and power in Day 12

	Case 1 - without mirror and without fan			Case 2 - with mirror and without fan			Case 3 - with mirror and with fan		
Time (S)	**Voltage (V)**	**Current (A)**	**Power (W)**	**Voltage (V)**	**Current (A)**	**Power (W)**	**Voltage (V)**	**Current (A)**	**Power (W)**
10:30 AM	18.6	0.88	16.37	18.91	0.93	17.59	18.91	0.93	17.59
11:00 AM	19.82	0.92	18.23	20.14	0.99	19.94	20.16	0.99	19.96
11:30 AM	20.81	1.11	23.10	21.21	1.19	25.24	21.44	1.21	25.94
12:00 PM	20.2	1.04	21.01	20.89	1.11	23.19	21.01	1.13	23.74
12:30 PM	21.21	1.09	23.12	21.41	1.21	25.91	21.52	1.23	26.47
1:00 PM	21.31	1.17	24.93	21.49	1.22	26.22	21.59	1.25	26.99
1:30 PM	21.01	1.13	23.74	21.47	1.19	25.55	21.57	1.21	26.10
2:00 PM	19.78	0.9	17.80	20.09	0.98	19.69	20.13	0.99	19.93
2:30 PM	21.31	1.16	24.72	21.73	1.23	26.73	21.99	1.25	27.49
3:00 PM	20.49	0.99	20.29	20.92	1.14	23.85	21.04	1.18	24.83
3:30 PM	20.44	0.99	20.24	20.81	1.09	22.68	21.01	1.13	23.74
4:00 PM	17.2	0.82	14.10	17.61	0.87	15.32	17.61	0.88	15.50
4:30 PM	16.82	0.71	11.94	17.21	0.8	13.77	17.21	0.8	13.77

In day 12, the currents and voltages of solar PV cells were recorded for different time interval nearly one and half Hour before of mid-day to observe the nature of conditional powers of solar cells. The data were plotted and calculated as powers lines shown in below graph. Before mid-day [11:00AM] the power of solar cell without mirror was 18.23 watts, with mirror was 19.94 watts and power output of solar cell with mirror subjected to air as a cooling medium was 27.49 watts. The power with mirror line fluctuated frequently as compared to the power without line. The maximum power for solar cell without mirror line was 24.93 watts at [1:00PM], maximum power of solar cell with mirror was 26.73 watts at [2:30PM] and maximum power of solar cell with plane mirror subjected to air as a cooling medium was 27.49 watts at [2:30PM]. The minimum power for solar cells without mirror was 11.94 watts at [10:30PM], for solar cells without mirror line was 13.77 watts at [04:30PM] and for solar cells with plane mirror subjected to air as a cooling medium was13.77 watts at [4:30PM].

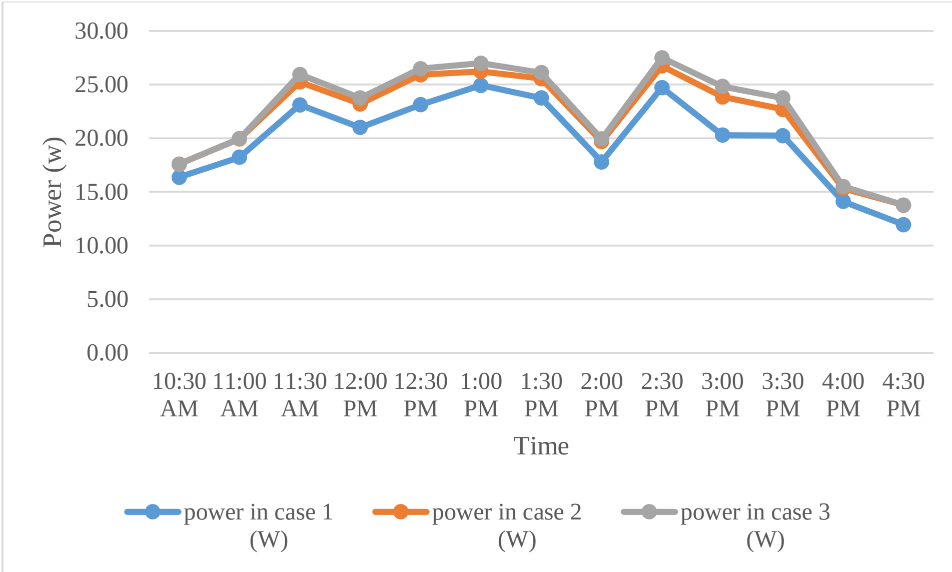

Figure 28 Power output of solar PV cells vs. different time of radiation in day 12

The high intense light falling on solar cells cause the temperature rise and as a result it affects the power line to fluctuate frequently while the less intense light falling on the cell surface couldn't increase such high temperature. Temperature of solar cell decreases the output power of solar cell.

Average power produced in case 1 = $\frac{259.59}{13}$ = 19.97 watts.

Average power produced in case 2 = $\frac{285.66}{13}$ = 21.97 watts.

Average power produced in case 3 = $\frac{292.03}{13}$ = 22.46 watts.

Table 24 Efficiency calculation in each case with data of day 12

Average power differences in case 1 & case 2	2.01 watts
Average power differences in case 1 & case 3	2.50 watts
Average power differences in case 2 & case 3	0.49 watts
% increment in efficiency of PV by using mirror	10.04%
% increment in efficiency of PV by using mirror & cooling medium	12.5%
% increment in efficiency of PV by using cooling medium in case 2	2.23%

It was found that, the power produced with using mirror gets increased up to 10.04% by utilization of plane mirror as concentrator and the power produced with using mirror gets increased up-to 12.5% by utilization of plane mirror as a concentrator and air as a cooling medium. The efficiency of air cooling to the arrangement of PV panel with plane mirror was found to be 2.23% in day 12.

Table 25 Data collection of voltage, current and power in Day 13

Time (S)	Case 1 - without mirror and without fan			Case 2 - with mirror and without fan			Case 3 - with mirror and with fan		
	Voltage (V)	Current (A)	Power (W)	Voltage (V)	Current (A)	Power (W)	Voltage (V)	Current (A)	Power (W)
10:30 AM	17.5	0.82	14.35	17.73	0.89	15.78	17.73	0.89	15.78
11:00 AM	19.82	0.94	18.63	19.99	1.11	22.19	20.01	1.13	22.61
11:30 AM	20.51	1.1	22.56	20.77	1.14	23.68	20.93	1.16	24.28
12:00 PM	21.4	1.17	25.04	21.62	1.21	26.16	21.67	1.22	26.44
12:30 PM	21.48	1.2	25.78	21.68	1.22	26.45	21.73	1.24	26.95
1:00 PM	20.8	1.12	23.30	21.21	1.17	24.82	21.49	1.2	25.79
1:30 PM	19.42	0.94	18.25	19.68	0.99	19.48	19.94	1.05	20.94
2:00 PM	18.14	0.89	16.14	18.72	0.96	17.97	18.81	0.97	18.25
2:30 PM	20.78	1.11	23.07	21.08	1.16	24.45	21.42	1.2	25.70
3:00 PM	20.92	1.14	23.85	21.31	1.17	24.93	21.5	1.21	26.02
3:30 PM	20.2	0.99	20.00	20.79	1.15	23.91	20.87	1.17	24.42
4:00 PM	18.42	0.88	16.21	18.91	0.99	18.72	18.92	0.99	18.73
4:30 PM	16.48	0.77	12.69	16.8	0.88	14.78	16.8	0.88	14.78

In order to examine the nature of the conditional powers of solar cells, the currents and voltages of solar PV cells were measured for various time intervals on day 4 roughly one and a half hours before midday. The data were computed as powers lines and plotted as seen in the graph below. Before mid-day i.e. at [11:30AM], the power of solar cell without mirror was 22.56 watts, with mirror was 23.68 watts and power output of solar cell with mirror subjected to air as a cooling medium was 24.28 watts. The power with mirror line fluctuated frequently as compared to the power without line. The maximum power for solar cell with mirror line was 26.45 watts at [12:30PM], for solar cell without mirror was 25.78 watts at [12:30PM] and solar PV cells with plane mirror subjected to air as a cooling medium was 26.95 watts at [12:30PM]. The minimum power for solar cells with mirror was 14.78 watts at [4:30AM], solar cells without mirror was 12.69 watts at [4:30 PM] and solar PV cells with plane mirror subjected to air as a cooling medium was14.78 watts at [4:30PM].

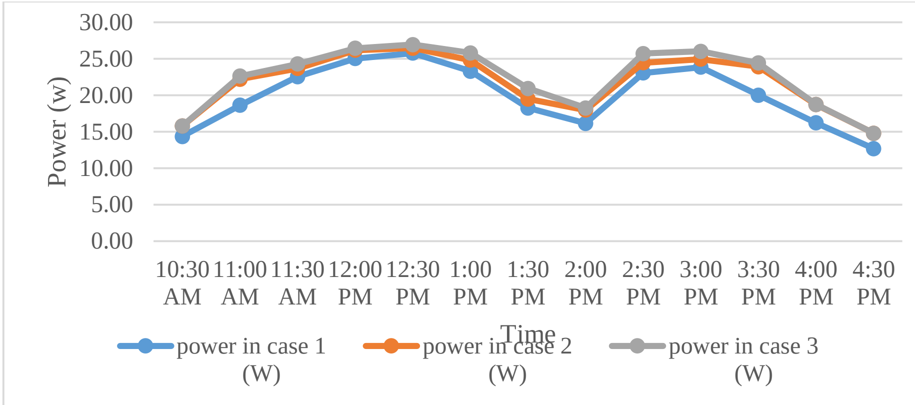

Figure 29 Power output of solar PV cells vs. different time of radiation in day 13

While less intense light falling on the cell surface couldn't raise such high temperatures, high intensity light falling on solar cells causes the temperature to rise and, as a result, it impacts the power line to vary often. The output power of a solar cell decreases with decrease in temperature.

Average power produced in case 1 = $\frac{259.86}{13}$ = 19.99 watts.

Average power produced in case 2 = $\frac{283.33}{13}$ = 21.79 watts.

Average power produced in case 3 = $\frac{290.67}{13}$ = 22.36 watts.

Table 26 Efficiency calculation in each case with data of day 13

Average power differences in case 1 & case 2	1.80 watts
Average power differences in case 1 & case 3	2.37 watts
Average power differences in case 2 & case 3	0.57 watts
% increment in efficiency of PV by using mirror	9.03%
% increment in efficiency of PV by using mirror & cooling medium	11.86%
% increment in efficiency of PV by using cooling medium in case 2	2.59%

It was found that, the power produced with using mirror gets increased up to 9.03% by utilization of plane mirror as concentrator and the power produced with using mirror gets increased up-to 11.86% by utilization of plane mirror as a concentrator and air as a cooling medium. The efficiency of air cooling to the arrangement of PV panel with plane mirror was found to be 2.59% in day 13.

Table 27 Data collection of voltage, current and power in Day 14

Time (S)	Case 1 - without mirror and without fan			Case 2 - with mirror and without fan			Case 3 - with mirror and with fan		
	Voltage (V)	Current (A)	Power (W)	Voltage (V)	Current (A)	Power (W)	Voltage (V)	Current (A)	Power (W)
10:30 AM	15.87	0.59	9.36	16.62	0.74	12.30	16.63	0.74	12.31
11:00 AM	17.43	0.83	14.47	17.87	0.87	15.55	17.91	0.87	15.58
11:30 AM	20.81	1.11	23.10	21.13	1.16	24.51	21.31	1.19	25.36
12:00 PM	19.94	1.01	20.14	20.81	1.14	23.72	20.95	1.19	24.93
12:30 PM	21.14	1.14	24.10	21.35	1.17	24.98	21.45	1.19	25.53
1:00 PM	21.22	1.16	24.62	21.45	1.2	25.74	21.55	1.21	26.08
1:30 PM	20.42	1.07	21.85	20.82	1.11	23.11	20.98	1.13	23.71
2:00 PM	20.1	0.98	19.70	20.92	1.11	23.22	21.1	1.13	23.84
2:30 PM	20.92	1.13	23.64	21.31	1.15	24.51	21.44	1.19	25.51
3:00 PM	19.82	0.98	19.42	20.51	1.11	22.77	20.72	1.13	23.41
3:30 PM	20.2	1.04	21.01	20.98	1.16	24.34	21.05	1.17	24.63
4:00 PM	18.1	0.87	15.75	18.52	0.94	17.41	18.56	0.95	17.63
4:30 PM	17.1	0.77	13.17	17.64	0.81	14.29	17.65	0.81	14.30

In day 14, data were shown in the graph below for conditional output powers of cells. These statistics have been impacted by seasonal clouds in part. It revealed that at [11:00AM], solar cells without mirrors produced 14.47 watts of electricity, solar cells with mirrors produced 15.55 watts, and solar cells with mirrors exposed to air as a cooling medium produced 15.58 watts. With regard to duration, intensity, and cell temperature, the power varied up and down and eventually declined. At [1:00PM] and [10:30AM], respectively, the greatest and minimum power without utilizing a mirror were 24.62 watts and 9.36 watts. For solar cells with a mirror, the greatest and minimum power values were 25,74 watts at [1:00 PM] and 12,30 watts at [10:30 AM], respectively. For cells with a mirror exposed to air as a cooling medium, the maximum and minimum power values were 26.08 watts at [1:00AM] and 12.31 watts at [10:30AM], respectively.

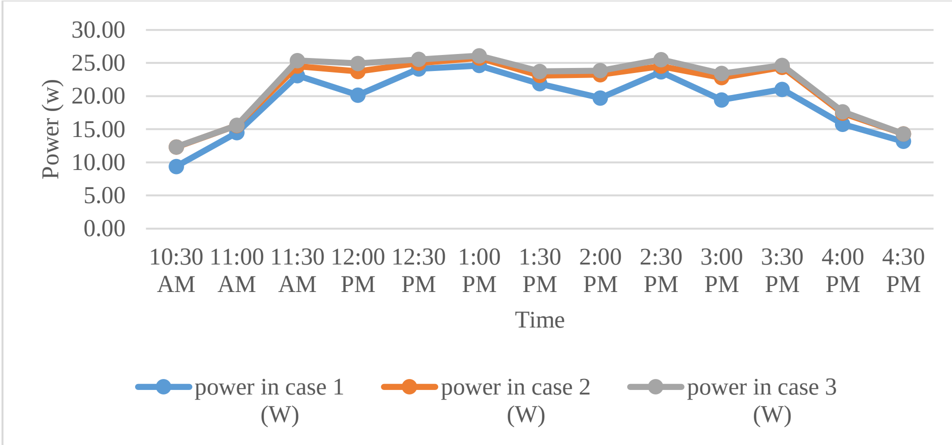

Figure 30 Power output of solar PV cells vs. different time of radiation in day 14

Average power produced in case 1 = $\frac{250.32}{13}$ = 19.26 watts.

Average power produced in case 2 = $\frac{276.44}{13}$ = 21.26 watts.

Average power produced in case 3 = $\frac{282.81}{13}$ = 21.75 watts.

Table 28 Efficiency calculation in each case with data of day 14

Average power differences in case 1 & case 2	2.01 watts
Average power differences in case 1 & case 3	2.50 watts
Average power differences in case 2 & case 3	0.49 watts
% increment in efficiency of PV by using mirror	10.44%
% increment in efficiency of PV by using mirror & cooling medium	12.98%
% increment in efficiency of PV by using cooling medium in case 2	2.31%

It was found that, the power produced with using mirror gets increased up to 10.44% by utilization of plane mirror as concentrator and the power produced with using mirror gets increased up-to 12.98% by utilization of plane mirror as a concentrator and air as a cooling medium. The efficiency of air cooling to the arrangement of PV panel with plane mirror was found to be 2.31% in day 14.

Table 29 Data collection of voltage, current and power in Day 15

Time (S)	Case 1 - without mirror and without fan			Case 2 - with mirror and without fan			Case 3 - with mirror and with fan		
	Voltage (V)	Current (A)	Power (W)	Voltage (V)	Current (A)	Power (W)	Voltage (V)	Current (A)	Power (W)
10:30 AM	15.41	0.52	8.01	15.92	0.64	10.19	15.94	0.64	10.20
11:00 AM	16.69	0.64	10.68	17.22	0.71	12.23	17.25	0.72	12.42
11:30 AM	19.82	0.97	19.23	20.45	1.08	22.09	20.81	1.12	23.31
12:00 PM	20.81	1.08	22.47	21.27	1.16	24.67	21.41	1.19	25.48
12:30 PM	19.42	0.91	17.67	20.11	0.96	19.31	20.71	0.98	20.30
1:00 PM	19.89	0.99	19.69	20.71	1.1	22.78	20.94	1.12	23.45
1:30 PM	21.2	1.14	24.17	21.37	1.17	25.00	21.51	1.21	26.03
2:00 PM	21.24	1.14	24.21	21.39	1.18	25.24	21.58	1.22	26.33
2:30 PM	21.04	1.11	23.35	21.35	1.18	25.19	21.52	1.21	26.04
3:00 PM	19.72	0.88	17.35	20.31	1.01	20.51	20.54	1.07	21.98
3:30 PM	19.11	0.81	15.48	19.92	0.98	19.52	20.04	1.01	20.24
4:00 PM	17.42	0.76	13.24	17.98	0.84	15.10	18.04	0.85	15.33
4:30 PM	16.81	0.69	11.60	17.21	0.75	12.91	17.22	0.75	12.92

In order to examine the nature of the conditional powers of solar cells, the currents and voltages of solar PV cells were measured for various time intervals on day 15 roughly one and a half hours before midday. The data are shown and calculated as powers lines in the graph below. Before noon i.e. at [11:00AM], power of solar cells without a mirror was 10.68 watts, power of solar cells with a mirror was12.23 watts, and power of solar cells with a mirror exposed to air as a cooling medium was 12.42 watts. The power with mirror line fluctuated frequently as compared to the power without line. The maximum power for solar cell without mirror was 24.21 watts at [2:00PM], maximum power of solar cell with mirror was 25.24 watts at [2:00PM] and maximum power of solar cell with plane mirror subjected to air as a cooling medium was 26.33 watts at [2:00PM]. The minimum power for solar cells without mirror was 8.01 watts at [10:30AM], minimum power for solar cells with mirror line was 10.19 watts at [10:30AM] and minimum power for solar cells with plane mirror subjected to air as a cooling medium was 10.20 watts at [10:30AM].

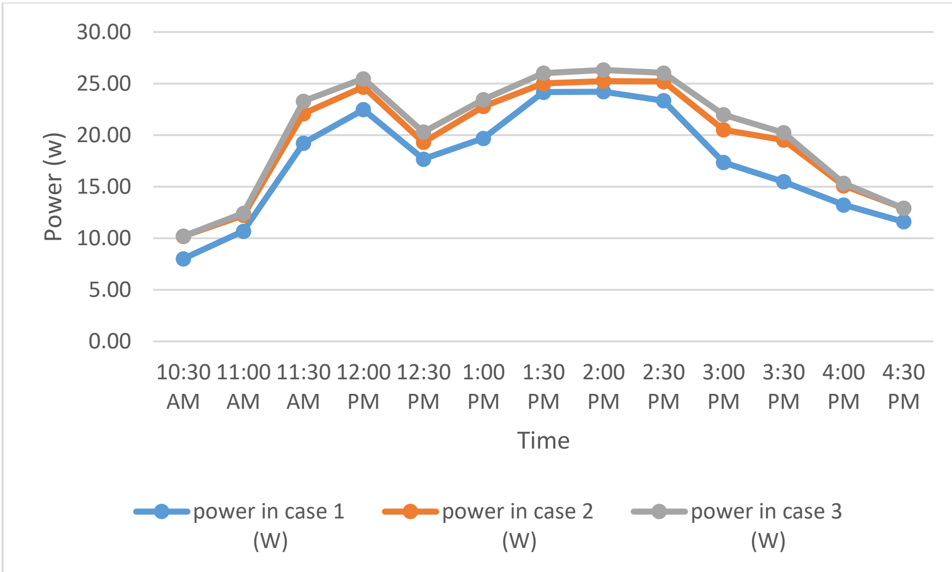

Figure 31 Power output of solar PV cells vs. different time of radiation in day 15

The high intense light falling on solar cells cause the temperature rise and as a result it affects the power line to fluctuate frequently while the less intense light falling on the cell surface couldn't increase such high temperature. Temperature of solar cell decreases the output power of solar cell.

Average power produced in case 1 = $\frac{227.17}{13}$ = 17.47 watts.

Average power produced in case 2 = $\frac{254.74}{13}$ = 19.60 watts.

Average power produced in case 3 = $\frac{264.02}{13}$ = 20.31 watts.

Table 30 Efficiency calculation in each case with data of day 15

Average power differences in case 1 & case 2	2.12 watts
Average power differences in case 1 & case 3	2.83 watts
Average power differences in case 2 & case 3	0.71 watts
% increment in efficiency of PV by using mirror	12.14%
% increment in efficiency of PV by using mirror & cooling medium	16.22%
% increment in efficiency of PV by using cooling medium in case 2	3.64%

It was found that, the power produced with using mirror gets increased up to 12.14% by utilization of plane mirror as concentrator and the power produced with using mirror gets increased up-to 16.22% by utilization of plane mirror as a concentrator and air as a cooling medium. The efficiency of air cooling to the arrangement of PV panel with plane mirror was found to be 3.64% in day 15.

4.4 Average Power Increment

The average power produced without using mirror gets increased up to 9.09% by utilization of plane mirror as concentrator. Utilizing a plane mirror as a concentrator and air as a cooling medium raises the average power generated without a mirror by 12.42 percent. The percentage increment in efficiency of PV by using mirror with air cooling medium i.e. addition of cooling medium in case two raises to 3.04 percent.

Table 31 Average increase in efficiency of solar PV cells in each case

Data taken in	% increment in efficiency of PV by using mirror (In case 2)	% increment in efficiency of PV by using mirror & cooling medium (In case 3)	% increment in efficiency of PV by using air cooling medium with respect to case 2
Day 1	14.01 %	18.75 %	4.16 %
Day 2	10.99 %	13.93 %	2.65 %
Day 3	7.69 %	10.89 %	2.97 %
Day 4	6.68 %	10.47 %	3.55 %
Day 5	6.89 %	9.33 %	2.28 %
Day 6	7.34 %	10.33 %	2.78 %
Day 7	8.12 %	11.72 %	3.32 %
Day 8	6.16 %	8.94 %	2.62 %
Day 9	10.70 %	15.84 %	4.64 %
Day 10	11.42 %	16.28 %	4.36 %
Day 11	7.69 %	10.00 %	2.15 %
Day 12	10.04 %	12.50 %	2.23 %
Day 13	9.03 %	11.86 %	2.59 %
Day 14	10.44 %	12.98 %	2.31 %
Day 15	12.14 %	16.22 %	3.64 %
Average	**9.09 %**	**12.42 %**	**3.04 %**

4.5 Intensity of Light

Light intensity is a measurement of the amount of power either emitted or reflected by a source, and it can be calculated using either the total wave output, luminosity, or brightness. In this case, the power of light is calculated with the measured voltage and current obtained from solar cells and area of solar cell is calculated exactly with the help of panel area, cell-cell gap area, column-column gap area.

Intensity of light (I) = power (P)/Area (a)

Table 32 Equivalence Intensity converted by PV cells in each case in day 5, day10, day12 and day15

Time	Intensity of light in day 5 without mirror (w/m^2)	Intensity of light in day 5 with mirror (w/m^2)	Intensity of light in day 10 without mirror (w/m^2)	Intensity of light in day 10 with mirror (w/m^2)	Intensity of light in day 12 without mirror (w/m^2)	Intensity of light in day 12 with mirror (w/m^2)	Intensity of light in day 15 without mirror (w/m^2)	Intensity of light in day 15 with mirror (w/m^2)
10:30 AM	186.64	197.29	52.70	61.63	160.80	172.77	78.72	100.10
11:00 AM	171.21	175.61	102.48	118.36	179.14	195.88	104.94	120.11
11:30 AM	145.31	154.58	179.51	204.63	226.93	247.96	188.87	216.98
12:00 PM	186.20	203.93	231.26	251.82	206.39	227.80	220.80	242.39
12:30 PM	223.77	230.31	221.80	231.62	227.12	254.51	173.61	189.66
1:00 PM	234.47	243.53	144.85	178.98	244.94	257.57	193.45	223.80
1:30 PM	231.62	243.30	137.70	157.72	233.24	251.00	237.43	245.63
2:00 PM	240.01	247.24	200.35	221.86	174.89	193.42	237.88	247.96
2:30 PM	229.66	237.32	213.54	236.42	242.85	262.58	229.44	247.50
3:00 PM	203.71	226.71	202.42	202.40	199.28	234.29	170.48	201.52
3:30 PM	193.32	225.13	134.49	174.72	198.80	222.84	152.07	191.78
4:00 PM	175.51	188.78	128.03	132.24	138.56	150.51	130.06	148.38
4:30 PM	143.47	167.98	82.76	91.44	117.32	135.26	113.95	126.81

Intensity of light was calculated as the ratio of power to the area of solar cells. The intensity of light varies from morning to evening. As the day forward the intensity of light increases. At noon the intensity of sunlight is high because the light falls to the cells are exactly perpendicular. The data taken from multimeter varies due to temperature of cells, intensity and seasonal clouds. In day 5, the intensity of light with mirror was greater than without mirror. It was clearly observed that the intensity graph with time is similar to the power graph with time of day 5.

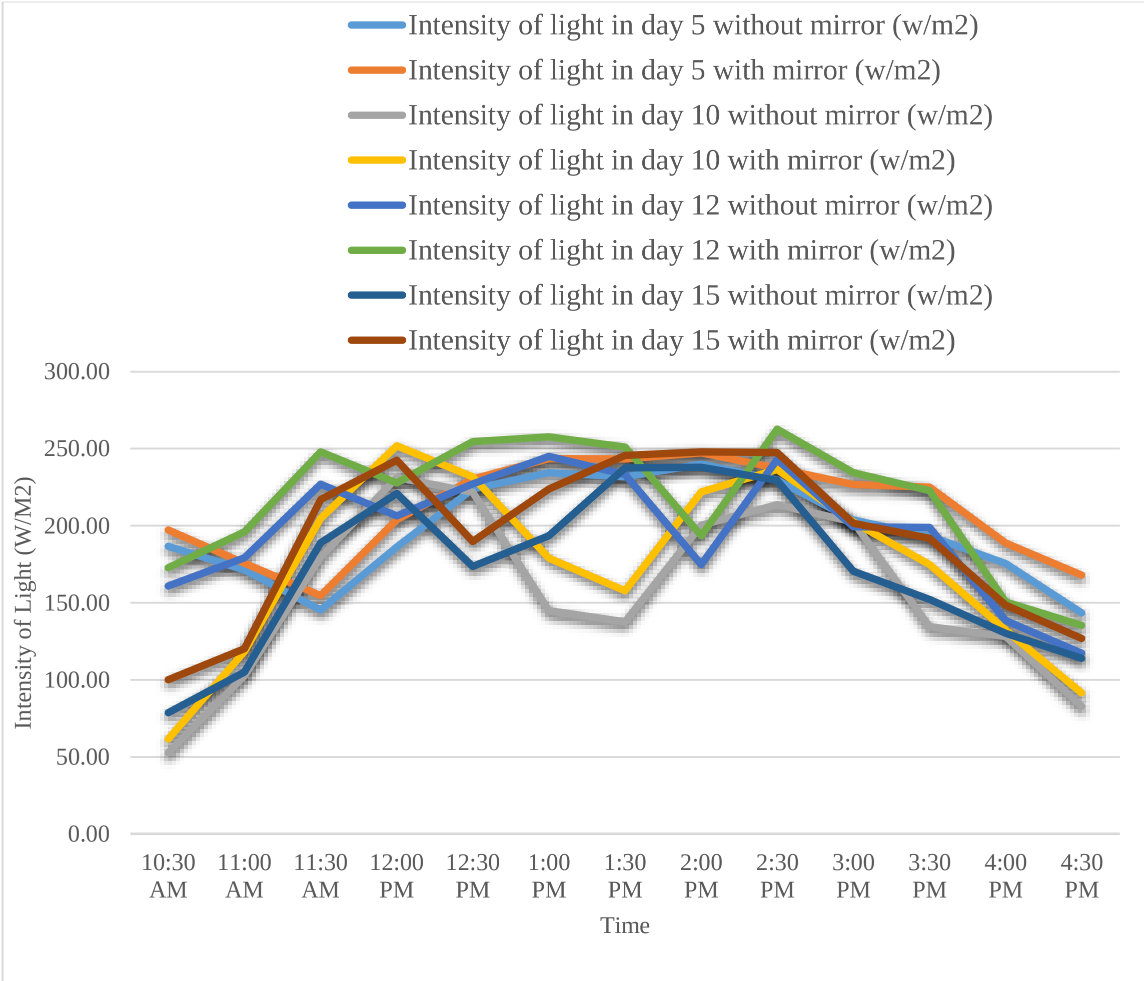

Figure 32 Intensity of light vs. time graph for day 5, day 10, day 12, day 15

In day 10, it was observed that the intensity graph of solar cell with respect to time varies from 12:50PM to 3:05PM and the intensity of light was calculated by calculating the area of solar cells covered and current and voltage obtained from solar cell recorded on the multimeter for specific time. It was observed that, the intensity of light with time plotted on the graph alongside. The graph represents that the intensity of light striking upon PV cells with mirror to the solar cells is high than the intensity of light on solar cells without mirror.

In day 12, the power of solar cell was calculated by multiplying the currents and voltages obtained for specific time. The graph of intensity was plotted by dividing the power calculated by area of solar cells .The plotted graph clearly shows that intensity of light on solar PV cells with mirror is high than the without mirror. The graph is similar to the power graph of day 12 with time.

In day 15, the intensity of light was observed and record the data of voltages and currents before nearly one hour of mid-day. The recorded data was plotted as line graph with time is similar to the power graph of day 15 with respect to time. The plotted graph clearly demonstrates that solar PV cells with mirrors receive more light than those without. The graph resembles the day 15 with time power graph.

The data obtained from the department of hydrology and meteorology were compared with the equivalent light intensity used by PV cells to produce electricity, it was found that there was minimal variance between the data from the experiment and the secondary source. Since the secondary data were taken from khumaltaar station, which was located at some distance from the pulchowk area, resulting some lower variations in final result of data when validating data obtained from the experiment with secondary source of data, the lower margin of error arises due to some limitations of data taking procedure like error of measuring instruments, environmental error etc.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The results of the experiment showed that whenever the solar panel was exposed to direct radiation and reflected radiation, its efficiency was increased up to a certain temperature limit. However, occasionally, due to a high intensity of solar radiation, the temperature of the PV panel crosses the optimum temperature value, causing a gradual decline in efficiency. Therefore, using solar PV panels with a flat reflecting mirror and a cooling medium produces the best efficiency output in hot weather condition.

The average power produced without using mirror gets increased up-to 9.09% by utilization of plane mirror as concentrator. This study shown that when solar PV cells with a plane mirror are exposed to air as a cooling medium, their performance increases by up to 12.42%. Adding an air cooling medium to solar PV cells with a plane mirror configuration resulted in an improvement in efficiency up to 3.04%.

By employing a plane mirror as a concentrator, it was demonstrated that a solar panel's light intensity rises with time, enhancing power production at lower radiation levels and assisting in providing the output needed in severe weather conditions.

5.2 Recommendation

The industrial manufacturing cost of solar panel is relatively high with its power production of it. This experimental study showed that efficiency of small powering panel can be increased by using concentrators like plane mirrors so, it is recommended that utilization of plane reflecting mirror and cooling medium were effective for increasing the performance of solar PV cells. Thus the effect of dust, snow, shade and irradiance fluctuation could be reduced with the use of plane mirror as reflector.

The average power produced without using mirror gets increased up-to certain percentage by utilization of plane mirror as concentrator which eventually helps to keep in balance of power in different adverse weather conditions. The effectiveness of plane mirror from the study demonstrates that this type of arrangement can be installed in larger capacity solar plants, which ultimately reduces overall cost in technical as well as financial aspects and can keep in balance of power output in various adverse weather conditions. This power can be used for industrial, agricultural, construction, educational and home purposes. This project is based upon the technical analysis of solar PV cells based upon different configurations.

Since it was not feasible to achieve continuous power production due to the rapid variations in light intensity caused by the changing weather in the local area, utilizing a plane reflector was an effective way to achieve continuous power output. Different hilly regions of Nepal have natural airflow that can be used for passive cooling, which would ultimately increase the effectiveness of solar panels with plane reflector configurations. Since financial analysis was not included in this paper, it is advised that future studies include financial analysis in relation to this subject.

REFERENCES

[1] Abd-elhady, M.S., Fouad, M.M. and Khalil, T. (2016) 'Improving the efficiency of photovoltaic (PV) panels by oil coating', ENERGY CONVERSION AND MANAGEMENT,115,pp.1–7.Availableat: https://doi.org/10.1016/j.enconman.2016.02.040.

[2] Abubakar, A. and Ali, M.H. (2017) 'Performance Improvement of Photovoltaic Module Using Plane Mirror',International Journal of Scientific and Research Publications, 7(4), p. 182. Available at: www.ijsrp.org.

[3] Alamri, F. et al. (2021) 'Analytical Modeling and Optimization of a Heat Sink Design for Passive Cooling of Solar PV Panel'.

[4] Arifin, Z. et al. (2020) 'Numerical and Experimental Investigation of Air Cooling for Photovoltaic Panels Using Aluminum Heat Sinks', 2020.

[5] Biber, M. et al. (2017) 'The influence of annealing temperature and time on the efficiency of pentacene: PTCDI organic solar cells', Results in Physics, 7, pp. 3444–3448. Available at: https://doi.org/10.1016/j.rinp.2017.09.014.

[6] Bilal, M. et al. (2016) 'Increasing the Output Power and Efficiency of Solar Panel by Using Concentrator Photovoltaics (CPV)', International Journal of Engineering Works, 3(12), pp. 98–102. Available at: https://hal.archives-ouvertes.fr/hal- 01430790%0Ahttps://hal.archives-ouvertes.fr/hal-01430790/document.

[7] Bube, R.H. and Fahrenbruch, A.L. (1981) Pbotovoltaic Effect.

[8] Deline, C. et al. (2013) 'A simplified model of uniform shading in large photovoltaic arrays', Solar Energy, 96(October 2013), pp. 274–282. Available at: https://doi.org/10.1016/j.solener.2013.07.008.

[9] Dhankhar, M., Pal Singh, O. and Singh, V.N. (2014) 'Physical principles of losses in thin film solar cells and efficiency enhancement methods', Renewable and Sustainable Energy Reviews,40(December),pp.214–223. Available at: https://doi.org/10.1016/j.rser.2014.07.163.

[10] DOE (2001) 'Concentrating solar power : Energy from mirrors', Energy efficiency and renewable energy, pp. 1–8. Available at: http://www.nrel.gov/docs/fy01osti/28751.pdf.

[11] Fraas, L. and Partain, L. (2010) Solar Cells and Their Applications, 2nd Edition (Wiley Series in Microwave and Optical Engineering).

[12] Gla, P.E. (1968) 'Power from the Sun : Its Futui re', Science, 162(3856), pp. 857–861.

[13] Gordon, J.M. and Wenger, H.J. (1991) 'CENTRAL-STATION SOLAR PHOTOVOLTAIC SYSTEMS : SENSITIVITY STUDIES Esst-West I Distance North- South Distance', 46(4), pp. 211–217.

[14] Is, S.C.H. (2010) 'An introduction to the paper by Abbott Keeping the Energy Debate Clean : How Do We Supply the World 's Energy Needs ?', An introduction to the paper by Abbott Keeping the Energy Debate Clean : How Do We Supply the World 's Energy Needs ?, 98(1), pp. 2009–2011.

[15] Julajaturasirarath, S., Jonburom, W. and Pornsuwancharoen, N. (2012) 'The experiment of double solar energy by reflection light method', Procedia Engineering,32,pp.522530.Availableat:https://doi.org/10.1016/j.proeng.2012.01. 1303.

[16] Luque-heredia, I. et al. (2003) 'A subdegree precision sun tracker for 1000X microconcentrator modules A SUBDEGREE PRECISION SUN TRACKER', (April 2015).

[17] Mendoza, B. (2005) 'Total solar irradiance and climate', Advances in Space Research,35(5),pp.882890.Available at:https://doi.org/10.1016/j.asr.2004.10.011.

[18] Mitchell, K., Nagrial, M. and Rizk, J. (2006) 'Optimisation of renewable energy systems', Renewable Energy and Power Quality Journal, 1(4), pp. 356–360. Available at: https://doi.org/10.24084/repqj04.455.

[19] Mitchell, K., Rizk, J. and Nagrial, M. (2006) 'Development of planning procedures with embedded solar systems', Australian Journal of Electrical and ElectronicsEngineering,3(1),pp.57–65.Availableat: https://doi.org/10.1080/1448837X.2006.11464145.

[20] Momirlan, M. and Veziroglu, T.N. (2005) 'The properties of hydrogen as fuel tomorrow in sustainable energy system for a cleaner planet', International Journal of Hydrogen Energy, 30(7), pp. 795–802. Available at: https://doi.org/10.1016/j.ijhydene.2004.10.011.

[21] Mousazadeh, H. et al. (2009) 'A review of principle and sun-tracking methods for maximizing solar systems output', Renewable and Sustainable Energy Reviews, 13(8), pp. 1800–1818. Available at: https://doi.org/10.1016/j.rser.2009.01.022.

[22] Paranthaman, M.P., Wong-Ng, W. and Bhattacharya, R.N. (2015) Semiconductor materials for solar photovoltaic cells, Semiconductor Materials for Solar Photovoltaic Cells. Available at: https://doi.org/10.1007/978-3-319-20331-7.

[23] Pearce, J.M. (2011) 'Digital Commons @ Michigan Tech A Review of Solar Photovoltaic Levelized Cost of Electricity', 15, pp. 4470–4482.

[24] Pearce, J.M. (2019) 'Photovoltaics - a path to sustainable futures To cite this version : HAL Id : hal-02120547 Photovoltaics – a Path to Sustainable Futures', 34(7), pp. 663–674. Available at: https://doi.org/10.1016/S0016.

[25] Popovici, G. et al. (2016) 'Efficiency improvement of photovoltaic panels by using air cooled heat sinks', 85(November 2015), pp. 425–432. Available at: https://doi.org/10.1016/j.egypro.2015.12.223.

[26] Rizk, J. and Nagrial, M. (2009) 'Impact of Reflectors on Solar Energy Systems', Technology,2(5),pp.563–567.Availableat: http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Impact+of+Reflectors +on+Solar+Energy+Systems#0.

[27] Taylor, P. (2011) 'Improving Photovoltaic Module', (April 2013), pp. 37–41. Available at: https://doi.org/10.1080/01457630802529214.

[28] Luque, S. H. (2003). Handbook of Photovoltaic Science and Engineering. Chichester: Wiley.

[29] Mani, M., & Pillai, R. (2010). Impact of dust on solar photovoltaic (PV) performance: Research status, challenges and recommendations. Renewable and Sustainable Energy Reviews, 3124-3131.

[30] Kempe, M. (2006). Modeling of rates of moisture ingress into photovoltaic modules. Solar Energy Materials and Solar Cells, 2720-2738.

[31] Weidong Xiao, W. G. Dunford, and A. Capel, 2004," A novel modeling method for PV cells", " In Proc. IEEE 35th Annual Power Electronics Specialists Conference, PESC", v. 3, p. 1950–1956.

[32] Y. Yusof, S. H. Sayuti, M. Abdul Latif, and M. Z. C. Wanik, 2004," Modeling and simulation of maximum power point tracker for PV system", "In Proc. National Power and Energy Conference, PECon", p. 88–93.

[33] A. Kajihara and A. T. Harakawa, 2005, "Model of PV cell circuits under partial shading", In Proc. IEEE International Conference on Industrial Technology, ICIT", p. 866–870. 2005.

[34] G. E. Ahmad, H. M. S. Hussein, and H. H. El-Ghetany, 2003, "Theoretical analysis and experimental verification of PV modules","Renewable Energy", 28(8):1159–1168.

[35] W. Kleinkauf, G. Cramer, and M. Ibrahim, 2005, "PV Systems Technology - State of the art developments and trends in remote electrification", "SMA Technologie AG".

[36] Poudyal, K., Bhattarai, B., Sapkota, B., & Kjeldstad, B. (2012). Estimation of Global Solar Radiation using Clearness Index and Cloud Transmittance Factor at Trans-Himalayan Region in Nepal. Energy and Power Engineering, 415-421.

[37] Bashir, M., Ali, H., Ali, M., & Siddiqui, A. (2013). An Experimental Investigation of Performance of Photovoltaic Modules in Pakistan. Thermal Science.

[38] Hohm, D. P. & M. E. Ropp, 2002, "Comparative Study of Maximum Power Point Tracking Algorithms"," Progress in PVs: Research and Applications", page 47-62.

APPENDIX

The temperature of solar PV panel was measured with the arrangement of Arduino Uno, temperature sensor, LCD display, current sensor and voltage sensor. The source code used in Arduino Uno associated with this arrangement was given below:

```
/*initialization function*/
void setup()
{
//serial connection setup
//opens serial port, sets data rate to 9600 bps
Serial.begin(9600);
//clear all data that’s been place in already
Serial.println("CLEARDATA");
//define the column headings (PLX-DAQ command)
Serial.println("LABEL,t,voltage,current,power");
}
/*the main code*/
void loop()
 {
//measuring voltage using "B25 0 to 25V" Voltage Sensor
//measuring current using "ACS 712" Current Sensor
//reading of the current and voltage from sensors
float voltage = analogRead(A0)*5*5.0/1023;
//PV panel voltage
float current = analogRead(A1)*5.0/1023;
 //PV panel current
```

```
Float power = voltage*current;
 //PV panel power
//allows the serial port to send data to Excel in real-time
Serial.print("DATA,TIME,");
// PLX-DAQ command
Serial.print(voltage);
//send the voltage to serial port
Serial.print(",");
Serial.print(current);
 //send the current to serial port
Serial.print(",");
Serial.println(power);
//send the power to serial port
delay(1000); //wait 1s before repeating
}
float temp;
int tempPin = 0;
void setup()
{
  Serial.begin(9600);
}
void loop()
{
  temp = analogRead(tempPin);
```

```
  // read analog volt from sensor and save to variable temp
  temp = temp * 0.48828125;
  // convert the analog volt to its temperature equivalent
  Serial.print("TEMPERATURE = ");
  Serial.print(temp); // display temperature value
  Serial.print("*C");
  Serial.println();
  delay(1000); // update sensor reading each one second
}
```

Measured Meteorological parameters provided by Department of Hydrology and Meteorology					
Date & Time	Irradiance (W/M^2)	Date & Time	Irradiance (W/M^2)	Date & Time	Irradiance (W/M^2)
6/22/2022 9:45	627.2	6/26/2022 9:45	19.9	7/1/2022 9:45	121.4
6/22/2022 10:45	637	6/26/2022 10:45	28.4	7/1/2022 10:45	179.7
6/22/2022 11:45	503.6	6/26/2022 11:45	95.6	7/1/2022 11:45	204
6/22/2022 12:45	1129.6	6/26/2022 12:45	200.2	7/1/2022 12:45	287.3
6/22/2022 13:45	992.8	6/26/2022 13:45	292.1	7/1/2022 13:45	353
6/22/2022 14:45	980.9	6/26/2022 14:45	291.8	7/1/2022 14:45	225.3
6/22/2022 15:45	740.6	6/26/2022 15:45	231.2	7/1/2022 15:45	179.5
6/22/2022 16:45	377.4	6/26/2022 16:45	384.9	7/1/2022 16:45	111.6
6/22/2022 17:45	228	6/26/2022 17:45	223.9	7/1/2022 17:45	101.4
6/23/2022 9:45	808.5	6/27/2022 9:45	383.1	7/2/2022 9:45	58.9
6/23/2022 10:45	776.9	6/27/2022 10:45	804.8	7/2/2022 10:45	112.6
6/23/2022 11:45	396.2	6/27/2022 11:45	954.6	7/2/2022 11:45	173.3
6/23/2022 12:45	793.5	6/27/2022 12:45	362	7/2/2022 12:45	199.8
6/23/2022 13:45	123	6/27/2022 13:45	444.2	7/2/2022 13:45	286.9
6/23/2022 14:45	222.9	6/27/2022 14:45	1003.7	7/2/2022 14:45	176.3
6/23/2022 15:45	464.9	6/27/2022 15:45	693.1	7/2/2022 15:45	86.3
6/23/2022 16:45	143.6	6/27/2022 16:45	193.2	7/2/2022 16:45	131.6
6/23/2022 17:45	84.7	6/27/2022 17:45	45.3	7/2/2022 17:45	64.6
6/24/2022 9:45	534.6	6/28/2022 9:45	347.3	7/3/2022 9:45	82.2
6/24/2022 10:45	727.8	6/28/2022 10:45	581.2	7/3/2022 10:45	282.9
6/24/2022 11:45	998.2	6/28/2022 11:45	761.7	7/3/2022 11:45	415.5
6/24/2022 12:45	887.5	6/28/2022 12:45	393.2	7/3/2022 12:45	551.7
6/24/2022 13:45	432.5	6/28/2022 13:45	216.9	7/3/2022 13:45	530.3
6/24/2022 14:45	411.4	6/28/2022 14:45	264	7/3/2022 14:45	886.1
6/24/2022 15:45	388.5	6/28/2022 15:45	273.1	7/3/2022 15:45	422.9
6/24/2022 16:45	279.7	6/28/2022 16:45	457.3	7/3/2022 16:45	279.6
6/24/2022 17:45	157.6	6/28/2022 17:45	121.3	7/3/2022 17:45	262.7
6/25/2022 9:45	215.8	6/29/2022 9:45	284.9	7/4/2022 9:45	361.2
6/25/2022 10:45	412.5	6/29/2022 10:45	438.5	7/4/2022 10:45	898.6
6/25/2022 11:45	467.4	6/29/2022 11:45	789.7	7/4/2022 11:45	900.3
6/25/2022 12:45	513.3	6/29/2022 12:45	406.9	7/4/2022 12:45	298.6
6/25/2022 13:45	455	6/29/2022 13:45	638.6	7/4/2022 13:45	939.9
6/25/2022 14:45	243	6/29/2022 14:45	308.5	7/4/2022 14:45	781.7
6/25/2022 15:45	203.3	6/29/2022 15:45	428.7	7/4/2022 15:45	736.7
6/25/2022 16:45	131.2	6/29/2022 16:45	368.4	7/4/2022 16:45	244.1
6/25/2022 17:45	88.1	6/29/2022 17:45	161.8	7/4/2022 17:45	311.2
6/24/2022 17:45	157.6	6/30/2022 9:45	163.5	7/5/2022 9:45	512.7

6/25/2022 9:45	215.8	6/30/2022 10:45	274.9	7/5/2022 10:45	481.6
6/25/2022 10:45	412.5	6/30/2022 11:45	426.2	7/5/2022 11:45	998.8
6/25/2022 11:45	467.4	6/30/2022 12:45	685.4	7/5/2022 12:45	661.5
6/25/2022 12:45	513.3	6/30/2022 13:45	446.3	7/5/2022 13:45	590.8
6/25/2022 13:45	455	6/30/2022 14:45	137.5	7/5/2022 14:45	109.9
6/25/2022 14:45	243	6/30/2022 15:45	105.7	7/5/2022 15:45	73.9
6/25/2022 15:45	203.3	6/30/2022 16:45	95.7	7/5/2022 16:45	72.7
6/25/2022 16:45	131.2	6/30/2022 17:45	32.4	7/5/2022 17:45	68.8
7/6/2022 9:45	648.3	7/10/2022 18:45	11.4	7/16/2022 9:45	123.7
7/6/2022 10:45	622.2	7/11/2022 9:45	170.1	7/16/2022 10:45	107.7
7/6/2022 11:45	372.4	7/11/2022 10:45	148	7/16/2022 11:45	208.4
7/6/2022 12:45	566.3	7/11/2022 11:45	262.2	7/16/2022 12:45	414.8
7/6/2022 13:45	445.1	7/11/2022 12:45	473.8	7/16/2022 13:45	240.4
7/6/2022 14:45	402.5	7/11/2022 13:45	353.5	7/16/2022 14:45	109.6
7/6/2022 15:45	432.4	7/11/2022 14:45	392.9	7/16/2022 15:45	146.6
7/6/2022 16:45	179.1	7/11/2022 15:45	517.5	7/16/2022 16:45	147.1
7/6/2022 17:45	176.9	7/11/2022 16:45	526.3	7/16/2022 17:45	74.9
7/7/2022 9:45	273.7	7/11/2022 17:45	188.5	7/17/2022 9:45	599.1
7/7/2022 10:45	376.5	7/12/2022 9:45	740.3	7/17/2022 10:45	769.1
7/7/2022 11:45	701.3	7/12/2022 10:45	1072.6	7/17/2022 11:45	577.7
7/7/2022 12:45	882.2	7/12/2022 11:45	285.3	7/17/2022 12:45	86.8
7/7/2022 13:45	495.6	7/12/2022 12:45	323.3	7/17/2022 13:45	233.1
7/7/2022 14:45	64.4	7/12/2022 13:45	306.8	7/17/2022 14:45	380.7
7/7/2022 15:45	255.4	7/12/2022 14:45	433.7	7/17/2022 15:45	115.1
7/7/2022 16:45	445.4	7/12/2022 15:45	493.5	7/17/2022 16:45	97.9
7/7/2022 17:45	169.2	7/12/2022 16:45	246.2	7/17/2022 17:45	43.8
7/8/2022 9:45	125.7	7/12/2022 17:45	11.7	7/18/2022 9:45	317.3
7/8/2022 10:45	277.7	7/13/2022 9:45	775.3	7/18/2022 10:45	500.8
7/8/2022 11:45	380.5	7/13/2022 10:45	981.8	7/18/2022 11:45	628.7
7/8/2022 12:45	143.3	7/13/2022 11:45	919	7/18/2022 12:45	755.2
7/8/2022 13:45	393.8	7/13/2022 12:45	421.8	7/18/2022 13:45	850.7
7/8/2022 14:45	339.7	7/13/2022 13:45	79.6	7/18/2022 14:45	824.4
7/8/2022 15:45	213.9	7/13/2022 14:45	211.5	7/18/2022 15:45	445.1
7/8/2022 16:45	84.3	7/13/2022 15:45	550.9	7/18/2022 16:45	518.3
7/8/2022 17:45	95.6	7/13/2022 16:45	572.1	7/18/2022 17:45	179.6
7/9/2022 9:45	328.3	7/13/2022 17:45	74	7/19/2022 9:45	392
7/9/2022 10:45	641.6	7/14/2022 9:45	882.8	7/19/2022 10:45	731.4
7/9/2022 11:45	810.5	7/14/2022 10:45	978.4	7/19/2022 11:45	479.2

7/9/2022 12:45	1133.1	7/14/2022 11:45	605.8	7/19/2022 12:45	682.4
7/9/2022 13:45	671.2	7/14/2022 12:45	103.4	7/19/2022 13:45	447.8
7/9/2022 14:45	599.1	7/14/2022 13:45	122.1	7/19/2022 14:45	248.5
7/9/2022 15:45	779.5	7/14/2022 14:45	473.3	7/19/2022 15:45	253.4
7/9/2022 16:45	366.4	7/14/2022 15:45	362.9	7/19/2022 16:45	93.2
7/9/2022 17:45	265.6	7/14/2022 16:45	432.5	7/19/2022 17:45	78.7
7/10/2022 9:45	851.4	7/15/2022 9:45	268.3	7/20/2022 9:45	433.8
7/10/2022 10:45	997.8	7/15/2022 10:45	466.6	7/20/2022 10:45	747.9
7/10/2022 11:45	694.4	7/15/2022 11:45	651.6	7/20/2022 11:45	228.8
7/10/2022 12:45	798.2	7/15/2022 12:45	724.7	7/20/2022 12:45	123.6
7/10/2022 13:45	313.1	7/15/2022 13:45	434.6	7/20/2022 13:45	104.8
7/10/2022 14:45	43.7	7/15/2022 14:45	272.4	7/20/2022 14:45	114.3
7/10/2022 15:45	30.4	7/15/2022 15:45	226.4	7/20/2022 15:45	100.4
7/10/2022 16:45	77	7/15/2022 16:45	116.3	7/20/2022 16:45	89.1
7/10/2022 17:45	24.1	7/15/2022 17:45	32.5	7/20/2022 17:45	84.5
7/21/2022 9:45	337.6	7/26/2022 10:45	271	7/31/2022 11:45	732
7/21/2022 10:45	554.8	7/26/2022 11:45	271.5	7/31/2022 12:45	983.1
7/21/2022 11:45	410.4	7/26/2022 12:45	234.2	7/31/2022 13:45	735.4
7/21/2022 12:45	412.8	7/26/2022 13:45	277.2	7/31/2022 14:45	606.6
7/21/2022 13:45	349	7/26/2022 14:45	223.7	7/31/2022 15:45	482.7
7/21/2022 14:45	310.9	7/26/2022 15:45	190.7	7/31/2022 16:45	99.6
7/21/2022 15:45	471	7/26/2022 16:45	229.4	7/31/2022 17:45	150.1
7/21/2022 16:45	242.9	7/26/2022 17:45	147.5	8/1/2022 9:45	378.9
7/21/2022 17:45	97.5	7/27/2022 9:45	426	8/1/2022 10:45	662.7
7/22/2022 9:45	563.8	7/27/2022 10:45	418.3	8/1/2022 11:45	654.5
7/22/2022 10:45	530.5	7/27/2022 11:45	263	8/1/2022 12:45	751.9
7/22/2022 11:45	687	7/27/2022 12:45	305.3	8/1/2022 13:45	643.9
7/22/2022 12:45	825.7	7/27/2022 13:45	468.7	8/1/2022 14:45	615.3
7/22/2022 13:45	425.2	7/27/2022 14:45	746.5	8/1/2022 15:45	677.2
7/22/2022 14:45	211.4	7/27/2022 15:45	432.7	8/1/2022 16:45	326.3
7/22/2022 15:45	305.8	7/27/2022 16:45	573.1	8/2/2022 9:45	611.5
7/22/2022 16:45	207.5	7/27/2022 17:45	215.9	8/2/2022 10:45	648.5
7/22/2022 17:45	152.1	7/28/2022 9:45	808.8	8/2/2022 11:45	775.6
7/23/2022 9:45	728.4	7/28/2022 10:45	686.8	8/2/2022 12:45	1055
7/23/2022 10:45	837.2	7/28/2022 11:45	519	8/2/2022 13:45	600.1
7/23/2022 11:45	980.9	7/28/2022 12:45	550.2	8/2/2022 14:45	381.8
7/23/2022 12:45	606.9	7/28/2022 13:45	696.6	8/3/2022 10:00	378.9
7/23/2022 13:45	242.1	7/28/2022 14:45	216.1	8/3/2022 11:00	662.7
7/23/2022 14:45	701.3	7/28/2022 15:45	509	8/3/2022 12:00	654.5

7/23/2022 15:45	441.9	7/28/2022 16:45	459.8	8/3/2022 13:00	751.9
7/23/2022 16:45	400	7/28/2022 17:45	154.2	8/3/2022 14:00	643.9
7/23/2022 17:45	124.5	7/29/2022 9:45	735	8/3/2022 15:00	615.3
7/24/2022 9:45	601.3	7/29/2022 10:45	946.2	8/3/2022 16:00	677.2
7/24/2022 10:45	623.8	7/29/2022 11:45	996.3	8/3/2022 17:00	326.3
7/24/2022 11:45	738.4	7/29/2022 12:45	655.5	8/4/2022 9:00	635.7
7/24/2022 12:45	1003.2	7/29/2022 13:45	635.6	8/4/2022 10:00	808.4
7/24/2022 13:45	1034.4	7/29/2022 14:45	761.7	8/4/2022 11:00	896
7/24/2022 14:45	767	7/29/2022 15:45	574.3	8/4/2022 12:00	901.3
7/24/2022 15:45	742.4	7/29/2022 16:45	499.6	8/4/2022 13:00	838.1
7/24/2022 16:45	282.5	7/29/2022 17:45	142	8/4/2022 14:00	288
7/24/2022 17:45	162.2	7/30/2022 9:45	196.2	8/4/2022 15:00	167.6
7/25/2022 9:45	424.2	7/30/2022 10:45	404.7	8/4/2022 16:00	300
7/25/2022 10:45	797.2	7/30/2022 11:45	631.4	8/4/2022 17:00	222.4
7/25/2022 11:45	746.1	7/30/2022 12:45	575.9	8/5/2022 9:00	635.7
7/25/2022 12:45	779.6	7/30/2022 13:45	1031.4	8/5/2022 10:00	808.4
7/25/2022 13:45	653.4	7/30/2022 14:45	475.4	8/5/2022 11:00	896
7/25/2022 14:45	471.4	7/30/2022 15:45	443.5	8/5/2022 12:00	901.3
7/25/2022 15:45	163.7	7/30/2022 16:45	285.8	8/5/2022 13:00	838.1
7/25/2022 16:45	55.6	7/31/2022 9:45	533.8	8/5/2022 14:00	288
7/26/2022 9:45	204.2	7/31/2022 10:45	842.7	8/5/2022 15:00	167.6
8/5/2022 16:00	300	8/6/2022 10:45	808.4	8/6/2022 13:45	838.1
8/5/2022 17:00	222.4	8/6/2022 11:45	896	8/6/2022 14:00	288
8/6/2022 9:45	635.7	8/6/2022 12:45	901.3	8/6/2022 14:45	167.6
8/6/2022 15:00	300	8/6/2022 16:45	263.4	8/7/2022 10:00	478.5
8/6/2022 15:45	222.4	8/6/2022 17:00	100	8/7/2022 11:00	296.3
8/6/2022 16:00	160	8/7/2022 9:00	534.7	8/7/2022 12:00	172.5