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Research Article

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Impact of Angle of Photovoltaic Panels' Inclination on Its Output Power

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Abstract The power generated by a photovoltaic panel depends not only on the intensity of the sunlight, but also on the angle it is inclined towards the sun. The impact of the angle of photovoltaic panels' inclination on its output power has been X-rayed. The output registers that power performance can be enhanced when a photovoltaic panel is inclined at an angle of between 40^0 to 50^0. There is a better power output result when the breath or thickness is the base than the length and the output performance is better when the photovoltaic panel assumes a position directly face to face with the sun than any other. An approximate model for the Output Power (Watt) of the photovoltaic panel (face to face with the sun) under similar conditions is stated thus: $P = I_{max}V_{max}$ SIN (2θ); where I_{max} = Maximum Output Current under a stated condition, V_{max} = Maximum Output voltage under a stated condition as I_{max} and θ = Angle of inclination of the photovoltaic panel ($0 < \theta > 90$).

Keywords Impact, Photovoltaic panel, Angle of inclination and Output power.

Introduction

The intensity of the sun varies by the clarity of the atmosphere and the angle at which the sun strikes a surface is called the "incident angle." The more perpendicular the sun's rays are to a surface, the more heat and light energy [1]. Incident solar radiation is the amount of solar radiation energy received on a given surface during a given time. Values are given in units of energy per area (W/m^2) and are usually the single most valuable metric for early design studies [1]. This is also sometimes called insolation (incident solar radiation) and is sometimes quoted in terms of energy accumulated per day or per year (kWh/m^2/day or kWh/m^2/yr). Incident solar radiation values are based on two primary components: Direct radiation from the sun which is always measured perpendicular to the sun's rays and Diffuse radiation that is both scattered by the clouds and atmosphere and the ground in front of the surface. This is always measured on a horizontal surface [1].

The power incident on a photovoltaic module depends not only on the power contained in the sunlight, but also on the angle between the module and the sun [2]. When the absorbing surface and the sunlight are perpendicular to each other, the power density on the surface is equal to that of the sunlight (in other words, the power density will always be at its maximum when the photovoltaic module is perpendicular to the sun) [2]. However, as the angle between the sun and a fixed surface is continually changing, the power density on a fixed photovoltaic module is less than that of the incident sunlight [2].

Photovoltaics is a simple and elegant method of harnessing the sun's energy [3]. Photovoltaic devices (solar cells) are unique in that they directly convert the incident solar radiation into electricity, with no noise, pollution or moving parts, making them robust, reliable and long lasting [3]. Solar cells are based on the same principles and materials behind the communications and computer revolutions, and this CDROM covers the operation, use and applications of photovoltaic devices and systems [3].

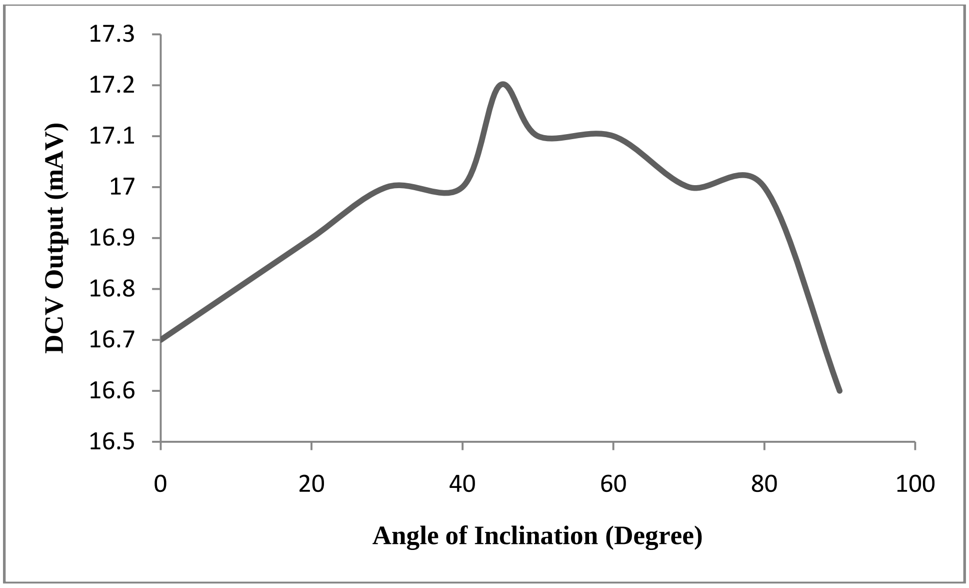
In order to produce the most electricity, the solar photovoltaic array should be orientated between south-east and south-west. It is not absolutely necessary for the array to face due south [4]. There will be only a small percentage power loss, as a result of moving a few degrees east or west of south. In trials, high annual yield values have been recorded for systems up to 30 degrees off south [4]. It is much more important to keep all system losses low than to optimise the orientation. More substantial output reductions are recorded where the orientation is more than 40 degrees off south (i.e. east of south-east or west of south-west [4].

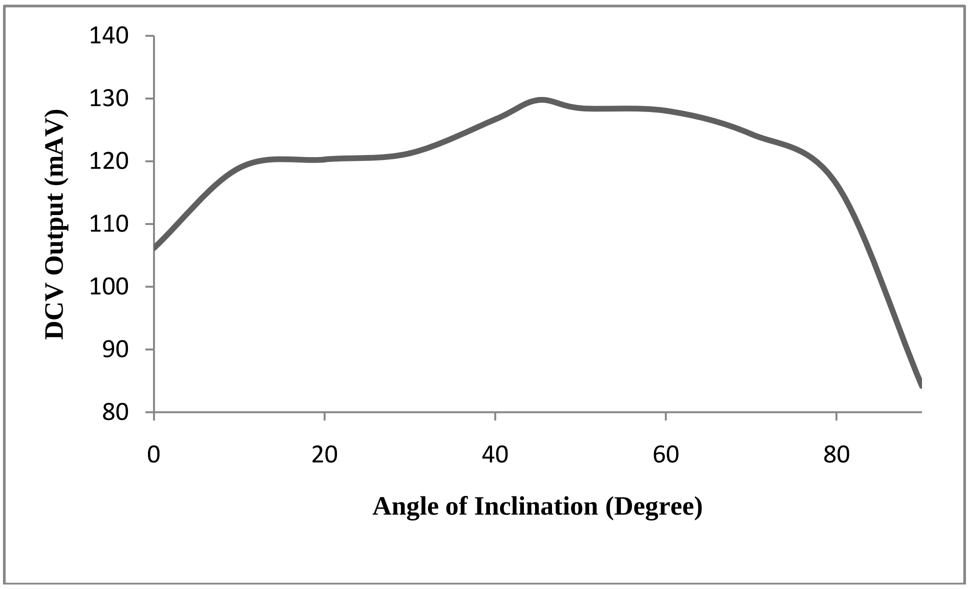
Solar panels are installed differently based on their geographic locations throughout the world. The premise behind this is simple; the sun is in a different place in the sky, so panels need to be directed according to this positioning [5]. The ideal situation is when the sun is hitting the panels at a perfectly perpendicular angle (90°) [5]. This maximizes the amount of energy striking the panels and being produced. The two factors that such an angle is controlled by are the orientation (North/South/East/West) and the angle of the panels from the surface of the Earth. So in Australia, what angle and orientation are best? [5].

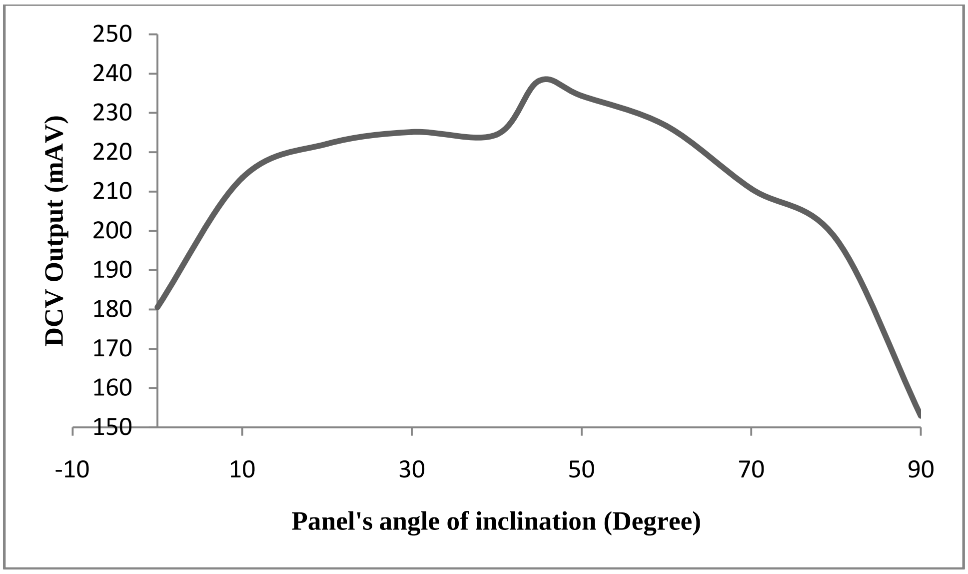
The aim of this research is to conduct an experiment to reach a conceivable conclusion on the effect of photovoltaic angle of inclination on the output power performance of a photovoltaic panel.

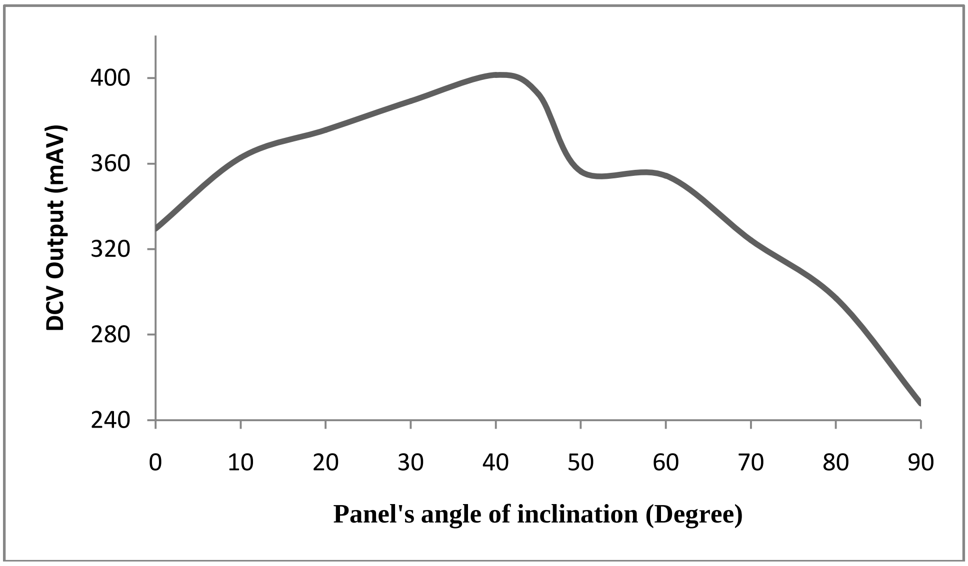
Experiment, Results and Discussion

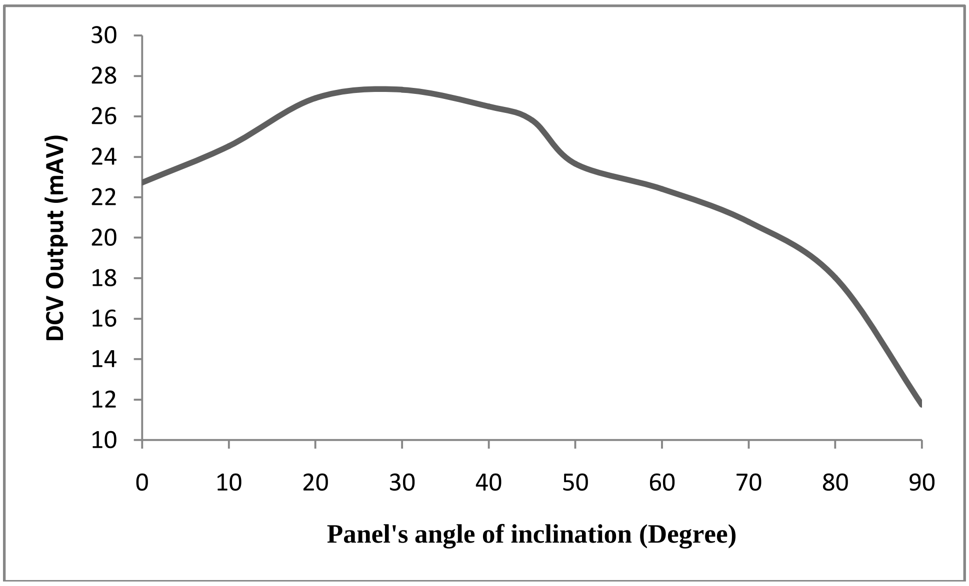
Under similar conditions including solar illuminance/intensity, the output current (short circuit currents) and output voltage (open circuit voltage) were measured with a multi-meter with the photovoltaic panels tilted at different angles of inclination towards the direction of the sun. The photovoltaic panel was exposed in an open space for direct solar radiation to rain on the panel. The power was computed for each output current and voltage. The following are the graphs of the data from measurements.

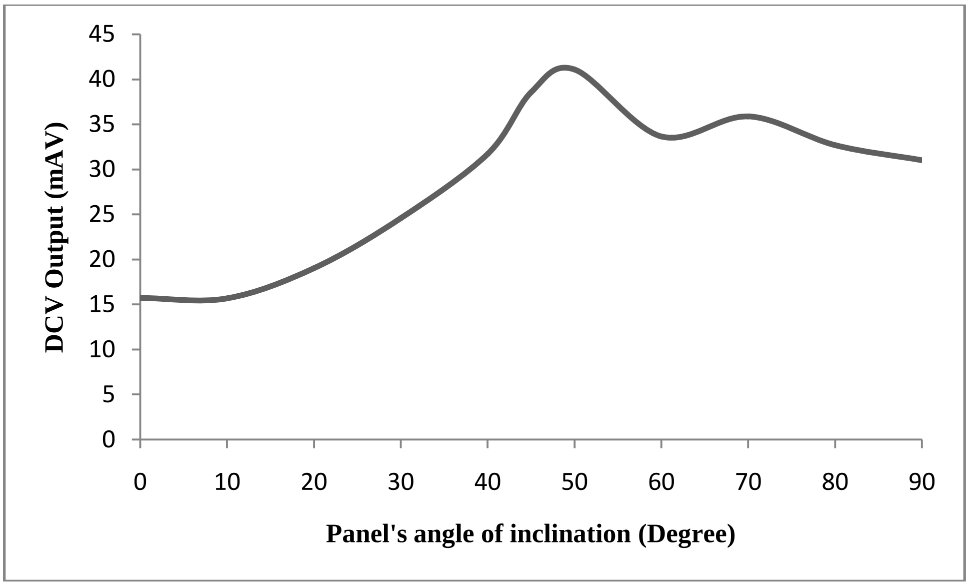





DCV Output (mAV)
250
240
230
220
210
200
190
180
170
160
150
-10
10
30
50
70
90
Panel's angle of inclination (Degree)


DCV Output (mAV)
400
360
320
280
240
0
10
20
30
40
50
60
70
80
90
Panel's angle of inclination (Degree)


DCV Output (mAV)
30
28
26
24
22
20
18
16
14
12
10
0
10
20
30
40
50
60
70
80
90
Panel's angle of inclination (Degree)



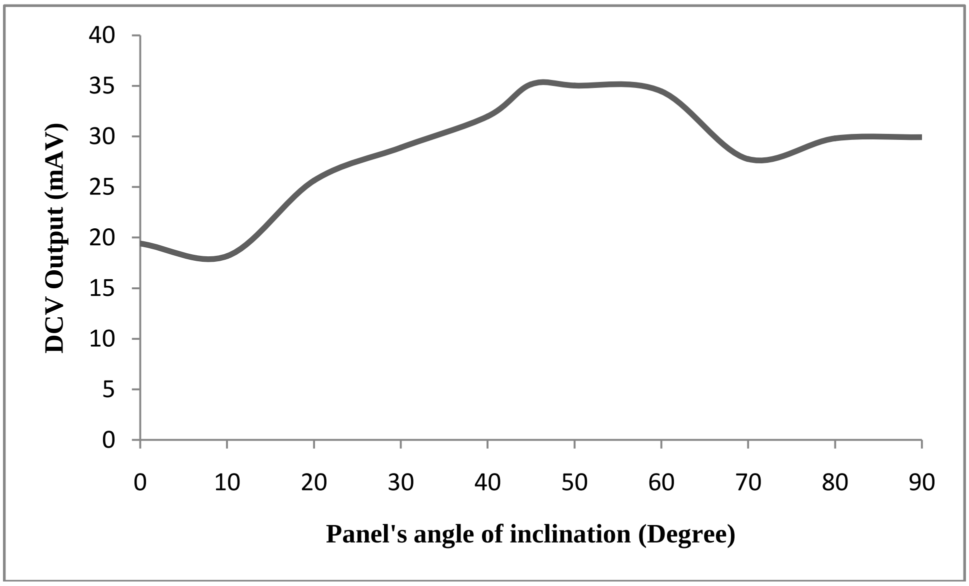


Figure 1: Output power against Photovoltaic panel's angle of inclination

From the graphical illustrations of results obtained from measurements, it is obvious that the angle of inclination of photovoltaic panels has a significant impact on its output performance. The inclination allows for a higher amount of photons (solar radiation particles) to fall on the face of the panel and induce photo currents and simultaneously voltage. From, studies a photon (a particle of sunlight) can only extract and excite an electron from a conductor or semiconductor, therefore the higher the amount of photons (sunlight particle) falling on the face photovoltaic panel (a semiconductor material) the higher the amount of electrons extracted and excited and invariably current and voltage.

The experiment still shows that, the power output performance is impaired in the panel as it is faced in the direction opposite the sun. This agrees with the fact that lesser amount of solar radiated particles will fall on the photovoltaic panel and lesser amount of current and voltage will be outputted.

Also, from the graphs in fig. 1 there is a range of angle of inclination that is favourable to the power output. The range of this angle of inclination of the photovoltaic panel is between 40^0 to 50^0. More so, for a rectangular panel, there is a better output result when the breath or thickness is the base (as shown in fig. 2(a)) than the length (as shown in fig. 2(b)). There is better output performance when the photovoltaic panel assumes a position directly face to face with the sun than any other.

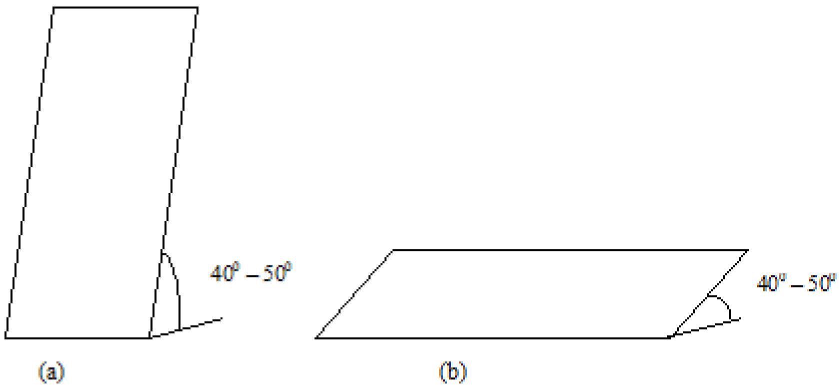


Figure 2: A rectangular photovoltaic panel inclined in two ways

The approximate model for the Output Power (Watt) of the photovoltaic panel (face to face with the sun) under similar conditions is stated thus:

$P = I_{max}V_{max}$ SIN (2θ)

Where I_{max} = Maximum Output Current under a stated condition

V_{max} = Maximum Output voltage under a stated condition as I_{max}

θ = Angle of inclination of the photovoltaic panel ($0 < \theta > 90$)

Conclusion

This paper has shown that the output power performance can be enhanced when a photovoltaic panel is jnclined at an angle between 40^0 to 50^0. There is a better power output result when the breath or thickness is the base than the length and the output performance is better when the photovoltaic panel assumes a position directly face to face with the sun than any other.

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