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The Behavior of the Solar Panel Temperature under Different Environmental Conditions

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Abstract

The temperature of the module is a parameter that affects the efficiency of the PV system exceptionally. It can modify the productivity of the scheme. In this research, the link between those parameters and the solar module's temperature was explored by several climate parameters. Solar radiation, ambient temperature and wind speed data have been analyzed in a particular site called Al-Diwaniyah - Iraq, for the period (January – December 2017). The outcomes demonstrate that there is a straight relationship between module temperature and ambient temperature. In addition, wind speed can play a significant impact on reducing the solar module temperature. Consequently, the conversion efficiency of PV panel decreases with increasing temperature.

Keyword: Solar Cell Temperature, Solar Radiation Rates, Ambient Temperature , Wind Speed.

1. Introduction

In the current scenario of solar energy, it is essential to assess high-quality energy efficiency [1]. The effective temperature of the solar panel producing energy is radically influenced both by the ambient air temperature and the sunlight levels. The photovoltaic (PV) module's operating temperature is described as contrary to electrical productivity. [2]. The effectiveness of the module has a depends on the absorption properties, heat dissipation , module encapsulating substance, the practical point of the solar panel, and climate parameters like irradiance level, enclosing temperature, wind speed and the particular installing requirements. Ambient temperature, solar radiation, and relative humidity are analyzed with sorts of modules and arrays characteristic [3]. In the current research, the environmental temperature and wind speed are only selected for consideration and the impression of these weather parameters is explained. The specific model determines average module temperature from wind speed, ambient temperature and irradiance and does not need the utilization of a specific cell temperature model [4].The temperature of the module as a means of heat dissipation decides the module temperature [5], such as the heat source (inflow), the ambient temperature and wind speed. An increase in operating temperature in a solar cell and the module reduces the band gap, which significantly increases the current in a solar cell's short-circuit, which causing a smaller filling factor and performance of the solar cell. The net effect leads to a direct connection to a PV module's electrical productivity [6].To predict the energy production of PV modules, it is necessary to anticipate the module temperature due to wind speed, ambient temperature, and all irradiance. The cell temperature can be calculated by the accompanying relationship (Kurtz) to a certain the temperature of the module [7].

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$$T_C = T_a + G.e^{-3.473-0.0594\,v_w} \quad (1)$$

G is the in-plane irradiance where T_a is the ambient temperature and v_w is the local wind speed close to the wind turbine. The Kurtz et al. equation does not recognize or differentiate between distinct PV technologies [7, 8].The power curve characteristic has a major impact on the temperature of the module. For crystalline silicone the open loop voltage is reduced significantly and increased to 0.45%/K with the PV module increasing its temperature, and the short circuit current only slightly increasing (range 0.04% and 0.09%/K). [9];

$$V_{o.c\,ambient} = Temperature\ coefficient\left[T_{STC}(C^\circ) - T_a(C^\circ)\right] + V_{o.c\,rated}(\mathrm{v}) \quad (2)$$

Where T_{STC} (ºC) is the temperature at standard test conditions, 25 ºC, T_a (ºC) is ambient temperature, $V_{o.c}$, rated is open circuit voltage at STC.

For solar concentrated energy (CSP), a wide ran ge of research groups[11-16]

have computed the thermal computational recept or under various conditions
extensively over recent years and one of the mos t comprehensive analysis
strategies is Wu et al.[17].

Procedure

The procedure to determine the PV module temperature incorporated into the common conditions depends on the idea that the contrast between the module temperature T_c and the ambient temperature T_a can be inspected as independent of the ambient temperature and directly corresponding to the irradiance at multi-levels over 100 W/m^2.

The system calls for sketching (T_c - T_a) versus irradiance for a time when wind conditions are ideal. All data practiced during the accompanying conditions must be rejected: irradiance below 100 W/m^2, wind speed over the range (0 - 8) m/s (S_0 - S_8), ambient temperatures exceeds the range (25 - 50) ºC, or differing by each for 10 min. Weather parameters data in this study, the global solar radiation, wind speed, and air temperature collected from the meteorological mast in Al-Diwaniyah location which was installed by the Ministry of Science and Technology- Renewable Energy Directorate. Data acquired at time interval of (10) minute. The geographical co-ordinates of the study site are (31 57.249 N, 44 46.611 E) .

2. Results and Discussion

Direct calculations of the cell temperature are not available for most PV installations. Therefore, it is attractive to parameterize the physical link between the PV cell temperature, surrounding irradiance and relevant meteorological parameters, for example, wind, which is the most essential part of changing the cell temperature. The traditional procedure used for handling a model depends on the irradiance of the in-plane irradiance and only prediction of ambient air temperature. The wind's effect on cell temperature is eliminated. Figure (1) shows the solar radiation rates for hours in which the solar panel is exposed to the radiation falling from it during the course of the year (100–900) W/m^2 at approximately (3721) hours., In comparing the time periods of solar radiation rates, it is noted that the time periods of solar radiation rates (400 - 900) W/m^2 that can be raise the temperature of the solar panel by more than (2000) hours.

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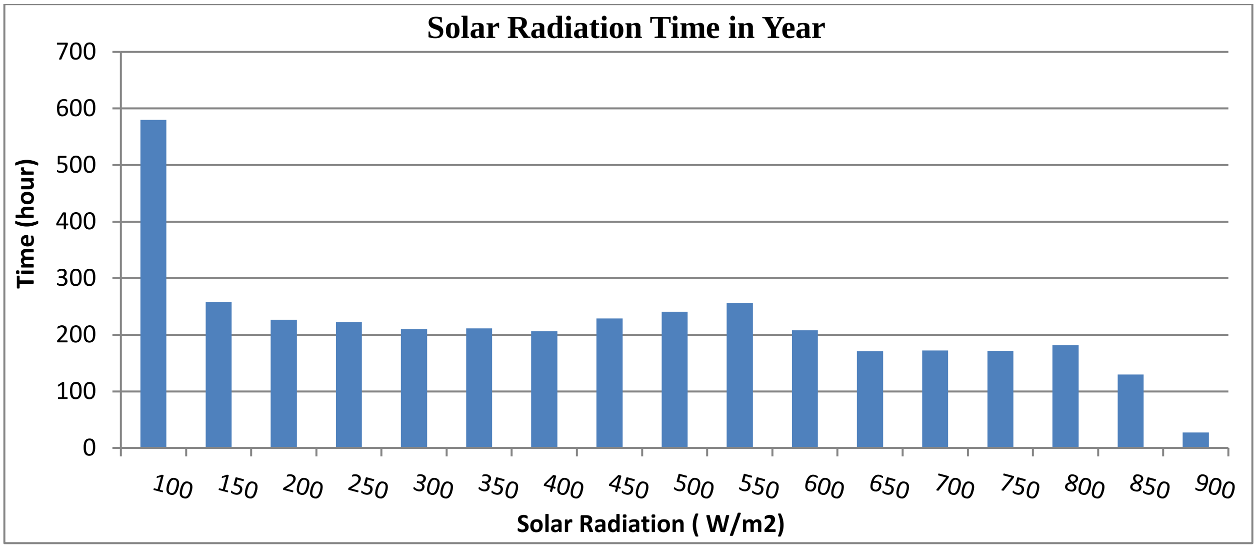

Fig 1- Time periods of solar radiation rates in a year

Ambient temperatures influence of the solar panel temperature by reducing the chance to dissipate energy to ambient . Figure (2) shows the ambient temperature time in year which the solar panel was exposed to it.

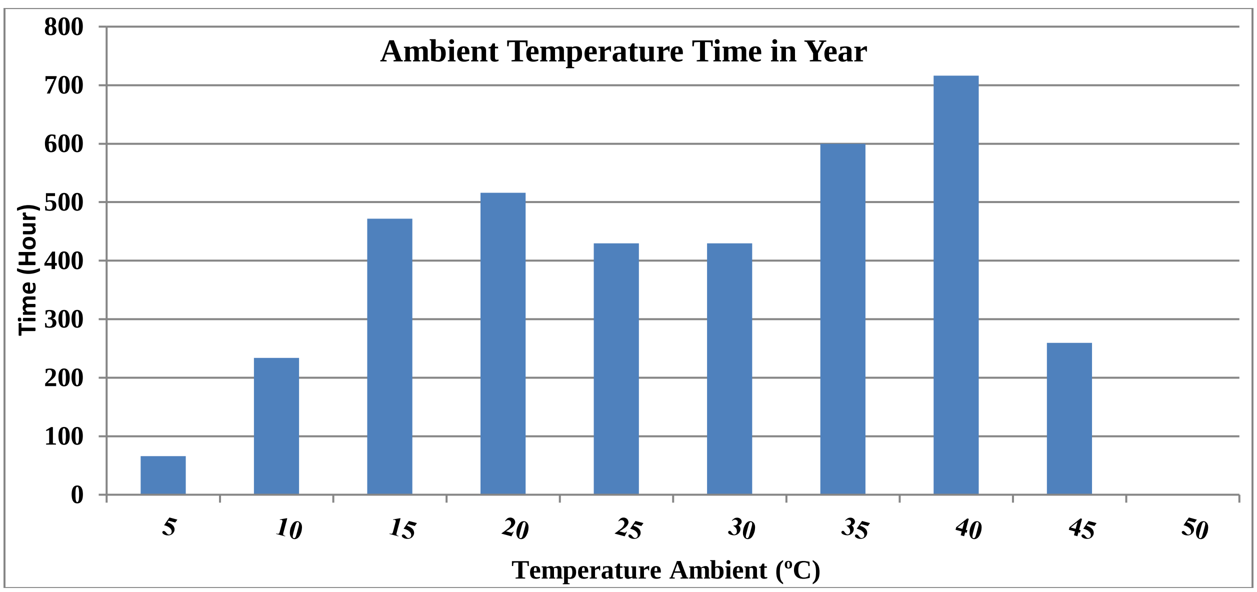

Fig 2- Ambient temperature time in a year

To calculate the wind time during the year, each wind speed was calculated and the time it takes shown in figure (3). The highest time and repetition which is expected to be impressive was for the speed (3,4,5,6) m/s, the least of which is the speed (0,1,2,7,8,9) , the speed that is expected to be ineffective because of their time and annual repetition (10,11,12,13).

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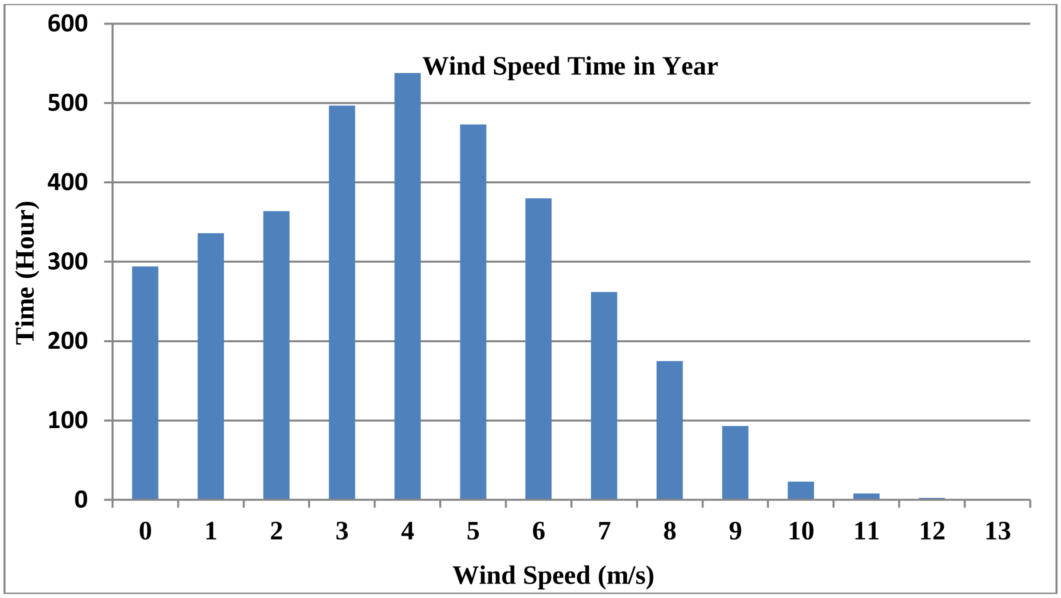

Fig 3- Wind speed time in a year

The equation (1) was used to calculate solar panel temperatures depended on solar radiation, ambient temperature, and wind speed data at the Al- Diwaniya site . The temperature of the solar panel was calculated from the ambient temperature (25-50) ºC, solar radiation (100 -1100) w/m^2 and wind speed (0 – 8) m/s, as shown in figures (4- 9) .The warming of the solar panel is observed with height ambient temperature of the same solar radiation rates, as the ambient temperature when is higher it works to prevent the dissipation of heat of the solar panel to the ambient. Although the presence of wind speed, high wind speed works little to dissipate the heat of the solar panel.

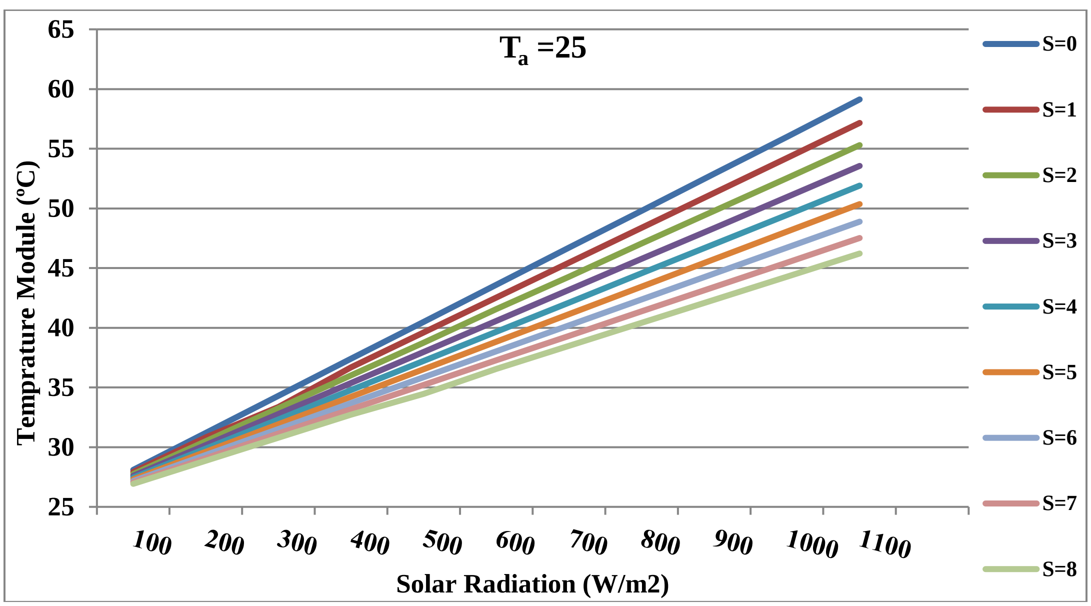

Fig 4- Temperature module with solar radiation for multi wind speed (S=0 to S=8) in ambient temperature 25 (ºC)

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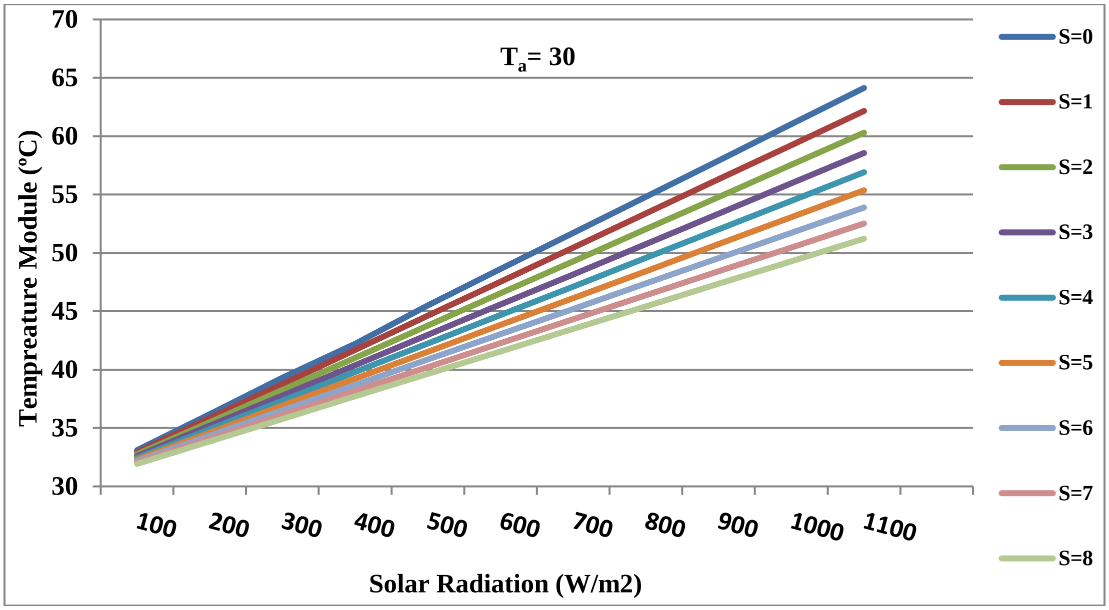

Fig 5- Temperature module with solar radiation for multi wind speed(S=0 to S=8) in ambient temperature 30(°C)

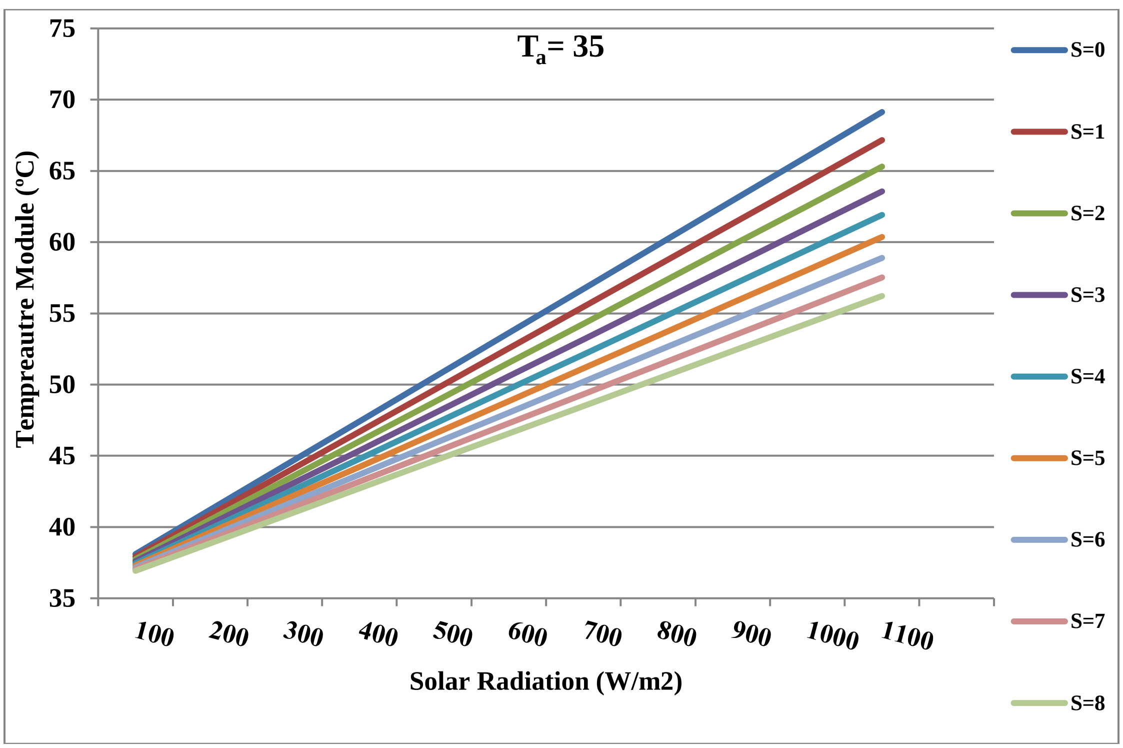

Fig 6- Temperature module with solar radiation for multi wind speed(S=0 to S=8) in ambient temperature 35 (°C)

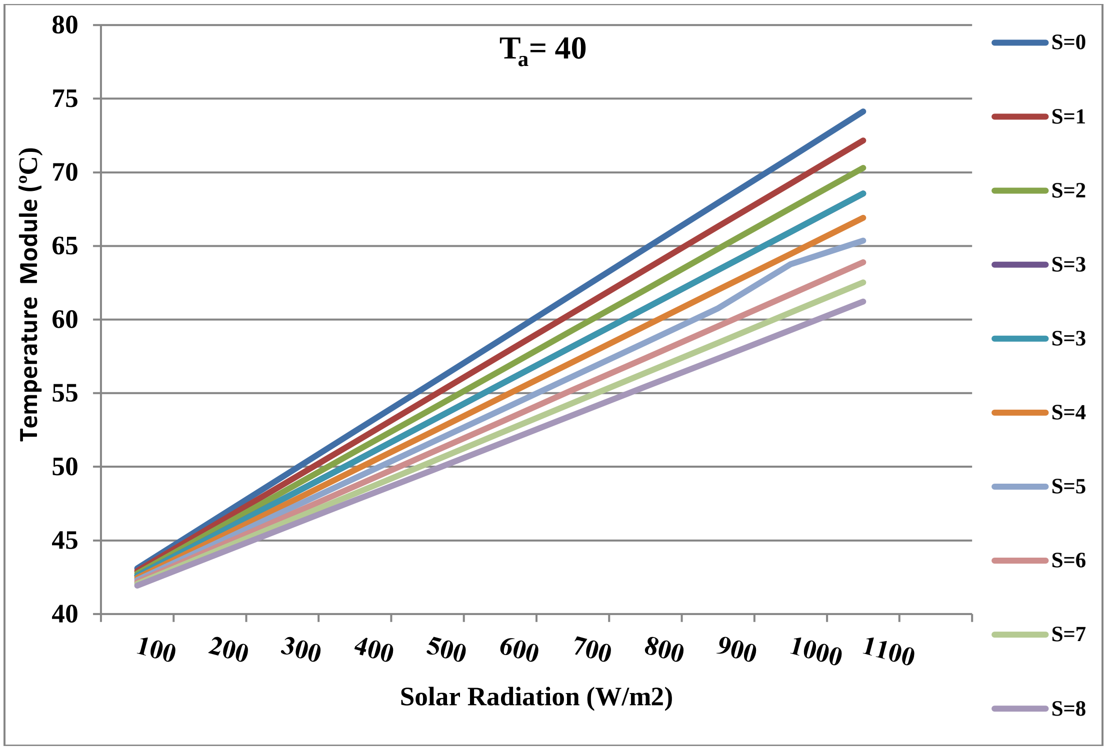

Fig 7- Temperature module with solar radiation for multi wind speed(S=0 to S=8) in ambient temperature 40 (ºC)

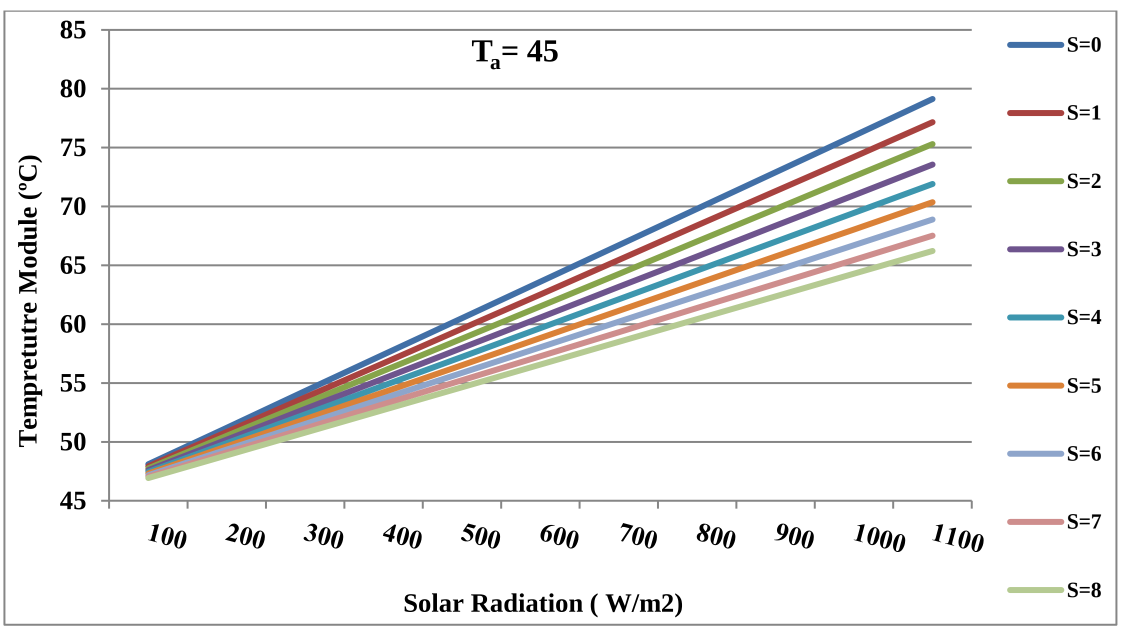

Fig 8- Temperature module with solar radiation for multi wind speed(S=0 to S=8) in ambient temperature 45 (ºC)

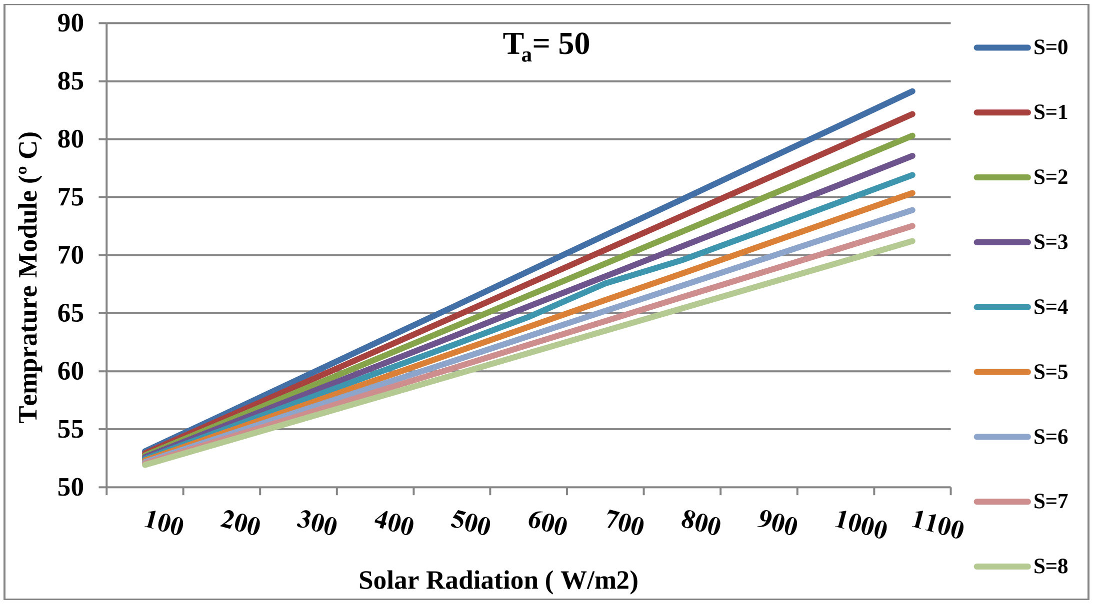

Fig 9- Temperature module with solar radiation for multi wind speed(S=0 to S=8) in ambient temperature 50 (ºC)

The equation (2) was used to calculate open circuit voltage for solar panel with ambient temperature, as shown in figure (10). Increases in ambient temperature lead to reduction open circuit voltage for solar panels thus reducing efficiency of solar panel.

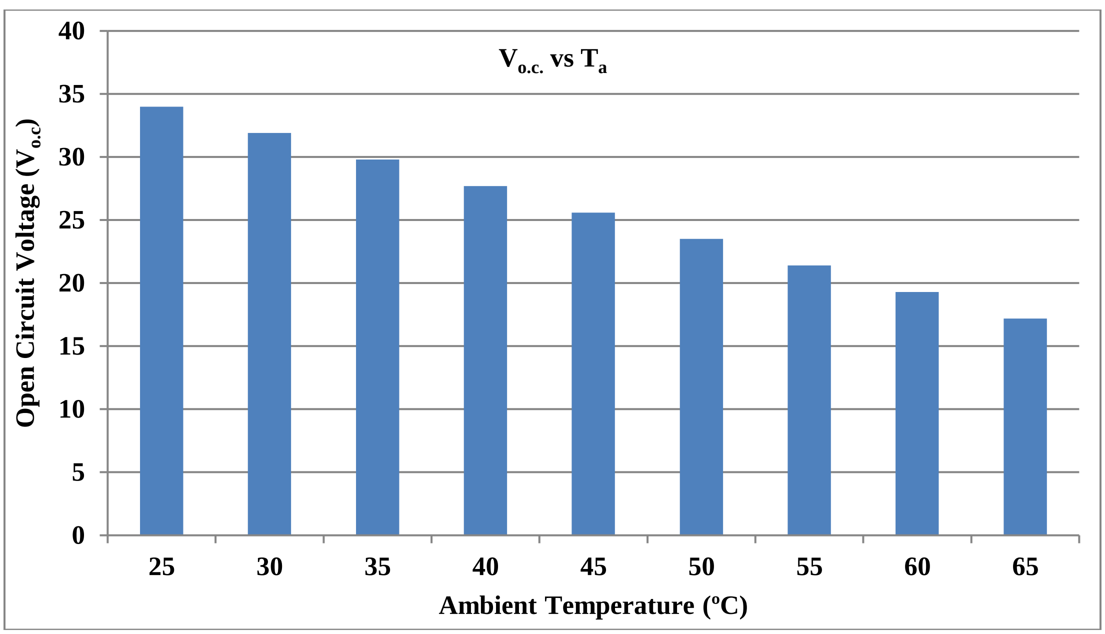

Fig 10- Open circuit voltage of solar panel with ambient temperature

It is clear that for each (1) ºC behind (25) ºC temperature increases led to decrease the open circuit voltage by (0.4-0.5) volt. Therefore it is preferable to install solar panels in a place with good ventilation and choices which have a small temperature coefficient and high efficiency to overcome the losses due to the high temperature

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Conclusions:

1- The findings show that the wind speed improves heat dissipation from solar panel
2- Solar panel temperature increases linearly with the increase of solar radiation and ambient temperature when there is no wind speed.
3- PV panel temperatures decrease approximately 13ºC when a considerable wind speeds available.
4- It is recommend installing solar energy systems in locations that have both moderate wind speed and high solar radiation.

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