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Evaluation of energy loss in solar panels in day-night circulation by MATLAB

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ABSTRACT

Fossil fuels as known as non-renewal sources which are mostly affect environment very adverse were extraction operations are costly which that the new-energy sources application is widely considered. The solar panels are the most effective devices for receive and control solar energy which focused on this study. The most important issue in solar cells is the problem of energy dissipation during day-night cycles. For this purpose, the particle swarm optimization (PSO) and perturb & observe (P&O) algorithms are utilized for evaluate the energy dissipation amounts were implemented in MATLAB. As basic of the analysis, Maragheh city's solar cells site is conducted to assessments. According to the results, the P&O method as well as PSO is suited for single-element solar radiation and for radiation/time response at tracking of maximum power point tracking (MPPT) were related to the day-night cycles.

1. Introduction

Renewal energy sources are the best option for replacement of traditional references which associated with many advantages such as low costs, clean environment, sustainability, renewable, low noise, recyclable, etc. which is considered as alternative energy sources for different countries (Villalva et al., 2009). Solar energy is applied in two different ways; it's most important application is that it can be turned in to heat such as CSP Solar heating cells and electricity such as PV solar panels. Solar heaters work through adsorption of solar energy and light radiation on adsorbent plates, and provide heating energy equivalent to optimal capacity (maximum absorption capacity in cells) for utilized installations (Sharma et al., 2012). Solar panels (a device that directly converts sunlight into electricity) have a performance similar to heating cells and are used to produce clean electricity (Veerachary et al., 2002; Nemet, 2009).

In the solar panels were used the technology for trapping the sunlight to generate electricity as main energy source. A photovoltaic solar panels (PV) module is a packaged, connected assembly of typically 6x10 photovoltaic solar cells which modules constitute the PV array of PV system that generates and supplies solar electricity in commercial and residential applications. The PV is use light energy (photons) from the Sun to generate electricity through the PV effect. The modules majority use wafer-based crystalline silicon cells or thin-film cells which as structural module member can either be the top or back layers. PV cells must be protected from mechanical damage, moisture, scratches, so mostly constructed rigid and some semi-flexibles (Veerachary et al., 2002). The cells must be connected electrically in series, one to another. The standard mechanism of the PV is illustrated in Fig. 1.

As mentioned before, the PV systems are trapped the sunlights and generates solar electricity which is directly affected by climate changes, season and day-night cycles. Because of that the PV cells output power is limited at high voltage levels which is a PV cells collection is commonly used as a primary component in large PV systems. Light intensity changing the incident on a solar cell changes all parameters in solar cell were names suns number (including the short-circuit current, the open-circuit voltage, the FF, the efficiency and the impact of series and shunt resistances) where 1 sun corresponds to standard illumination at 1 kW/m^2. A PV module designed to operate under 1 sun conditions is called a 'flat plate' module while those using concentrated sunlight are called 'concentrators' (Xiao, 2017).

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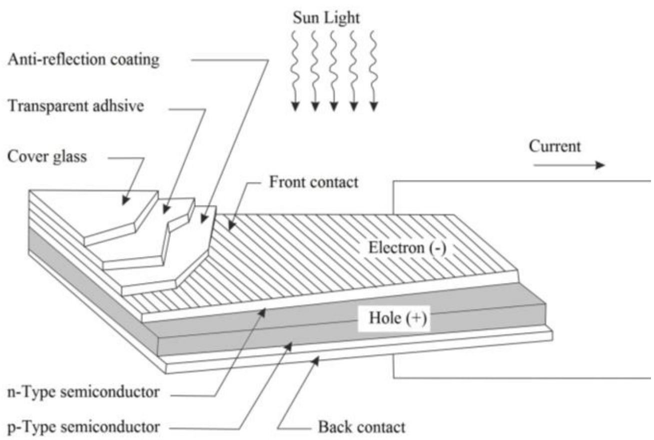

Figure 1. The mechanism of the PV system (Xiao, 2017)

2. Solar Cells Architecture

The objective of a PV cell is capture solar energy as much as possible and converts into electrical energy which trapping and controlling the solar energy reaching the Earth's atmosphere. This energy is blocked in the cells and absorb by absorber panels. Radiation absorption can occur on both sides of the junction, creating minority carriers that can diffuse towards the junction. A photocurrent is generated if the minority carriers can drift across the junction without recombination. In practice, the junction is shallow and absorption will occur predominantly on one side where there is a greater depth of absorbing material. So, one side of the junction is considered to be the absorber layer and it is the spectral absorption characteristics of this layer that will determine the maximum absorption possible from the available solar radiation (Kasap and Capper, 2017). This process is presented in Fig. 2.

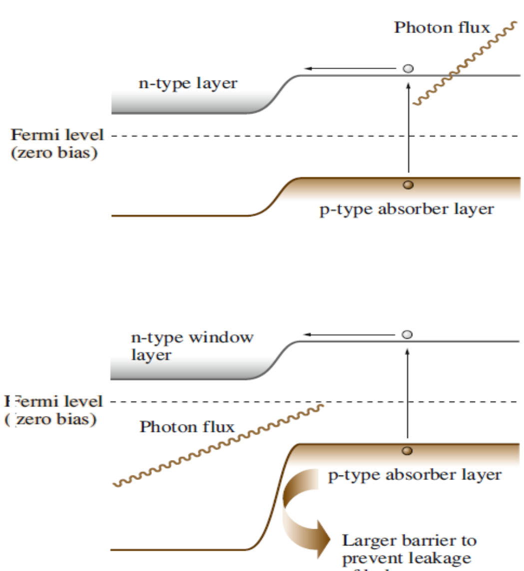

Figure 2. Schematic of an energy-band diagram for a standard solar cell (Kasap and Capper, 2017)

In the day-night cycles, the dark-light of sun pattern make the photon flux in the window-absorber layers are change which is by limitation of the sun radiation the energy trapping is ended and emancipation is started. An ideal diode characteristic of the day-night cycles in cell, In the dark the J–V plot would go through the origin and, as the light intensity increases, the short-circuit current becomes increasingly negative, indicating the presence of a photo -generated current. The equation for the J–V characteristic of this ideal device is followed (Kasap and Capper, 2017):

$$J = J_s\left(e^{\frac{qV}{k_BT}} - 1\right) - J_l \tag{1}$$

where J_s is the saturation current in reverse bias under zero illumination, q is the charge on the carrier, V is the applied voltage, k_B is Boltzmann's constant, T is the temperature of the cell and J_l is the photo-generated current. Power can be extracted from the device in the +V, -J quadrant of the J–V plot and the load will determine the operating point in this quadrant. The power is determined from the product JV at this operating point, shown graphically in Fig. 3. Also, maximum power will correspond to the operating point that will give the largest JV area on this graph. For the ideal diode characteristics given in Eq. 1, this maximum power is given by the following (Kasap and Capper, 2017):

$$P_m = J_m V_m$$

$$= J_m\left[V_{oc} - \frac{k_BT}{q}\ln\left(1 + \frac{qV_m}{k_BT}\right) - \frac{k_BT}{q}\right] = J_m\left(\frac{E_m}{q}\right) \tag{2}$$

where E_m is the maximum energy that can be extracted per photon and depends on the semi-conductor absorber layer band parameters which determine V_{oc} and V_m. According to the Fig. 3, two fundamental parameters which will limit the efficiency of the cell:

- The fraction of solar photons absorbed in the cell,
- The electrical energy created per photon.

The first factor can be calculated by integrating over the solar spectrum for the appropriate AM number and including the cutoff wavelength of the semiconductor absorber layer. The second efficiency factor implies that not all the photon energy will be converted into electrical energy, even if one photon absorbed constitutes one minority carrier crossing the junction.

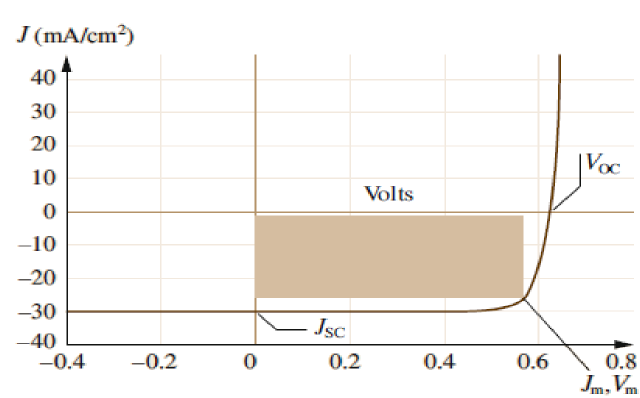

Figure 3. Ideal J–V characteristic for a PV cell

3. State of studied area

The studied area is Maragheh solar panels site is located in the Maragheh city which is the second largest city in the east-Azerbaijan province and it is special administrative center of Maragheh county were build along the Sufi-chay River on the southern of Sahand Mount and 135 kilometers south of the Tabriz as provincial capital. This city is located in the Urmia Lake eastern part on the southern hillside of Sahand Mount which it is limited from the north to the Tabriz city, from the east to Hashtrood, from the south to the Miandoab city and from the west to Urmia Lake (Azarafza and Mokhtari, 2013). Maragheh city has an area of 2647 hectares in alluvial of the Sufi-chay River. The climate of Maragheh is mild, cold and relatively humid were maximum temperature in the summer is about 35^{o}C and in winter it is about 20^{o}C below ZERO. Also, the annual rainfall in Maragheh is about 330 mm and its freezing season is about 114 days in a year. Geologically, the whole area of the city is covered by alluvial deposits (Agha-Nabati, 2007). Figure 4 shows the location of Maragheh solar panels site and Maragheh city in Iran in Google Earth.

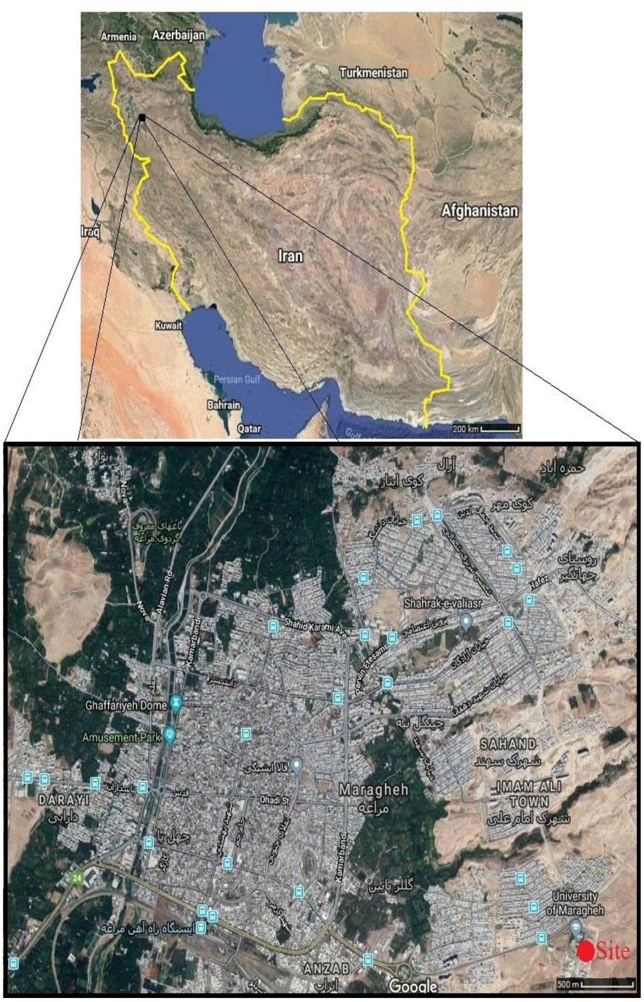

Figure 4. Location of the Maragheh solar panels site and Maragheh city in Google-Earth

4. Methodology

By growing the populations of Maragheh city, using the new sources of energy is required. In other hand, the solar energy is preparing the sustainable without creating much noise, toxic gases or greenhouse gases were considered for replacement energy sources. The solar energy is the easiest sources to achieve clean energy which is used in the world for producing the electrical energy. But, some issues are associated with these process which is must be considered. Climatological and day-night changes are the most effective condition in losing energy from the solar powers. Based on the geographic condition of the Maragheh city, the day-night cycle is the main parameter for losing the energy from the solar cells which that by association the city's climate make considerable affect on energy dissipation in PV. Due to these conditions, the PV energy module can be changed (Tajuddin et al., 2013). So, by simulation the day-night cycle (dark-light condition), we can evaluate the effect of these parameters on PV energy module which related to the PV energy dissipation. To this end, these conditions are considered in this study and simulated by MATLAB software. For this purpose, the radiation effects is simulated by using the particle swarm optimization (PSO) and perturb & observe (P&O) algorithms to achieve amounts of energy dissipation in solar cell.

5. Material and Methods

The PSO algorithm is global minimization method were can be used to solve problems that their answer is a point or a surface in the n-dimensional space by application of collective search algorithm that it modeled on social behavior of bird categories. Initially, this algorithm was used to explore the patterns governing the simultaneous flight of birds and the sudden change in their path and optimal deformation of the category. In PSO algorithm, particles are flowing in the search space. Maximum power point tracking is a method for maximizing the output power of wind turbines and photovoltaic systems. In this regard, it is tried to optimize the maximum power point tracking (MPPT) parameters using the PSO algorithm under the atmospheric variation conditions. For this purpose, a MPPT model was applied to the PSO algorithm and the P&O method was used, then the two methods were compared in terms of MPPT, energy, and lost energy. P&O is one of the algorithmic methods used to run an MPP and refers to the V-P characteristic curve of the PV cell. Therefore, with a periodic disruption (i.e., increase or decrease), the voltage of the output terminal of the PV cell and the comparison of the output power will work in the previous cycle (Miyatake et al., 2011). The Fig. 5 is presented the PV assessment flowchart based on PSO and P&O algorithms. As seen in this figure, the processing path is clearly considered to evaluate the maximum of MPPT to calculate the maximum energy dissipation in a case panel. Also, in Fig. 6, the mechanism of PV form the case study is presented.

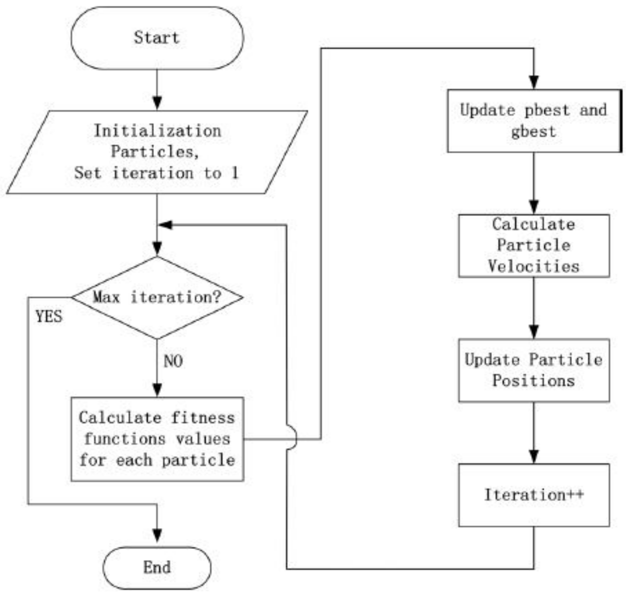

Figure 5. PSO and P&O application flowchart (Qin and Kimball, 2011)

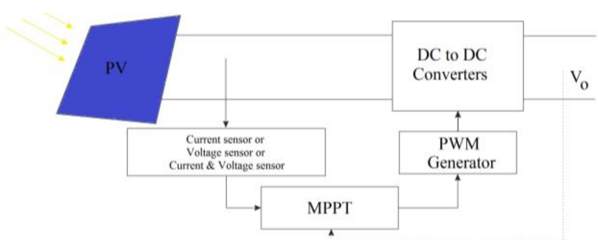

Figure 6. PV mechanism of work

6. Results and discussions

In order to evaluate the day-night changes effects on the performance of solar panels, two modeling groups have been carried out which is the first group is contain the basic simulation were conducted on constant day-to-day conditions and second group is a functional change that is caused by day-night status from studied cases which is verified by ground data where conducted for 500, 1000 and 1500 W/m^2 of solar energy adsorptions. It's should be note that the temperature is 308°K or 35°C and solar radiation is 1000 W/m^2 are considered as default data for simulations. For other features, Tr (temperature of the source cell) is 298°K. K_o (short circuit current temperature coefficient) is 6×10^{-4}, A (connection ideal factor) is 18, N (cells number) is 6, electron load is 1.6×10^{-19}, Boltzmann's constant is 1.38×10^{23}, and the energy of the semi-conducting band gap used in the cell is 6 EV. The results of the first constant condition evaluation of PSO and P&O algorithms is presented in Fig. 7. Also, the variation of temperature from day and night is presented in Fig. 8. As seen in this figure, achieved voltage from the day time and night time which is the 60 to 70 V are final stats. Figure 9 is presented the simulation results of the first group's results which is conducted for constant conditions. In Figs. 10 and 11, the simulation results of the second group are shown. Tables 1 and 2 are presented the losing energy results from the solar cell.

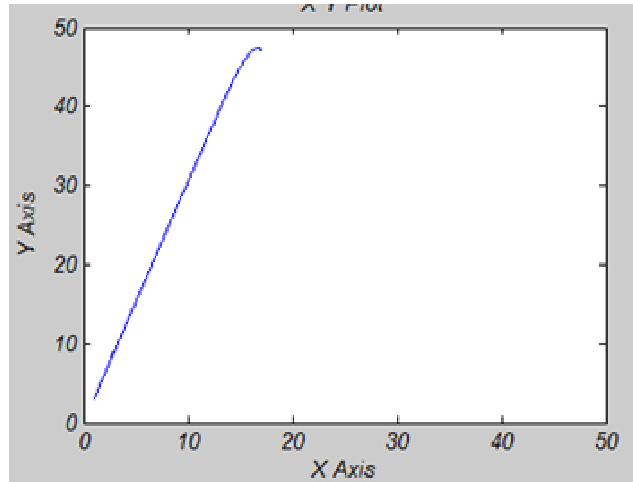

Figure 7. Untapped energy phenomenon (casualties)

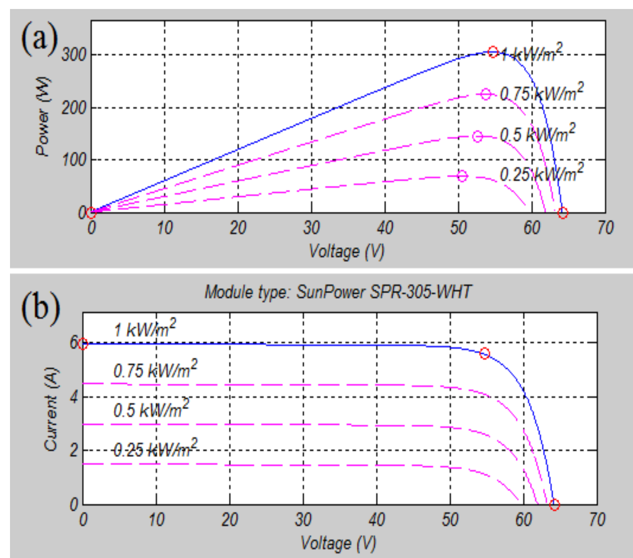

Figure 8. The effect of temperature function relative to variables on voltage-power diagram; (a) day, (b) night

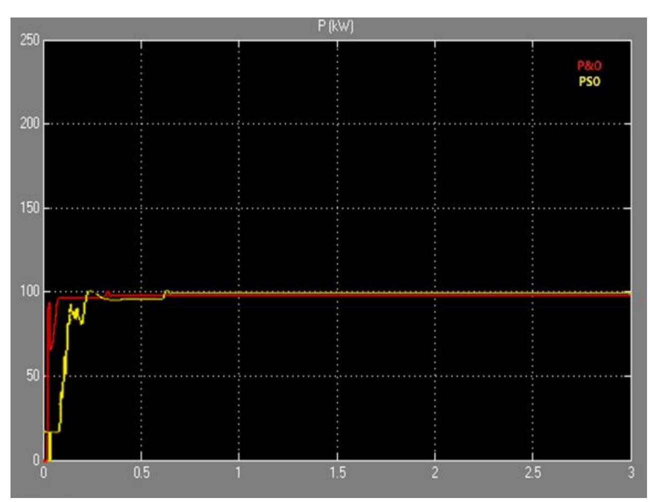

Figure 9. Assessment of the constant condition in day-night cycle

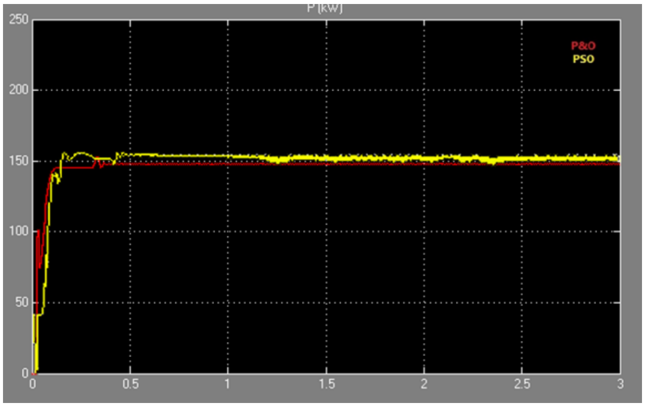

Figure 10. Assessment of the variable condition in day cycle

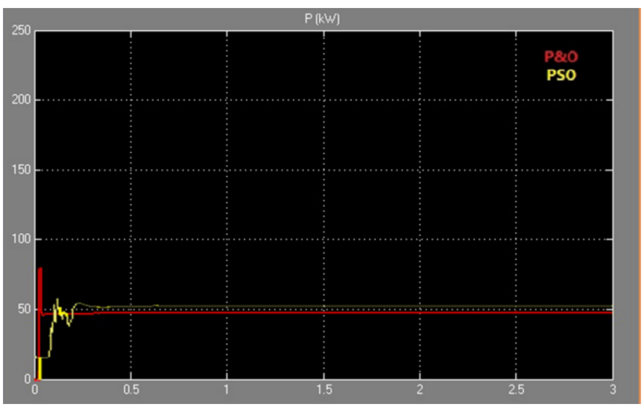

Figure 11. Assessment of the variable condition in night cycle

Table 1 Single radiation result for constant conditions

Solar energy (W/m^2)	P&O		PSO	
	Tracking power time (KW)	Obtained energy (KJ)	Tracking power time (KW)	Obtained energy (KJ)
500	44.40	87.40	47.51	79.56
1000	98.52	157.41	99.53	128.00
1500	148.71	202.31	150.4	189.56

Table 2 Single radiation result for variable conditions

Solar energy (W/m^2)	P&O		PSO	
	Tracking power time (KW)	Obtained energy (KJ)	Tracking power time (KW)	Obtained energy (KJ)
Day	69.24	214.09	74.01	278.1
Night	109.8	133.1	144.1	166.4

According to these figures, the night cycle is lost more them 50 W/m^2 in each cells which is related to cold situation in nights in Maragheh city were affected standard condition of analysis. Thus, assessment of the weathering and climatological conditions make to evaluate the realistic value of energy dissipation. However, based on the Tables 1 and 2 results, the energy lost amount is evaluated and presented in Fig. 12. According to this figure, differences between the constant condition and nigh loss energy are about 40 W/m^2 which are considerable.

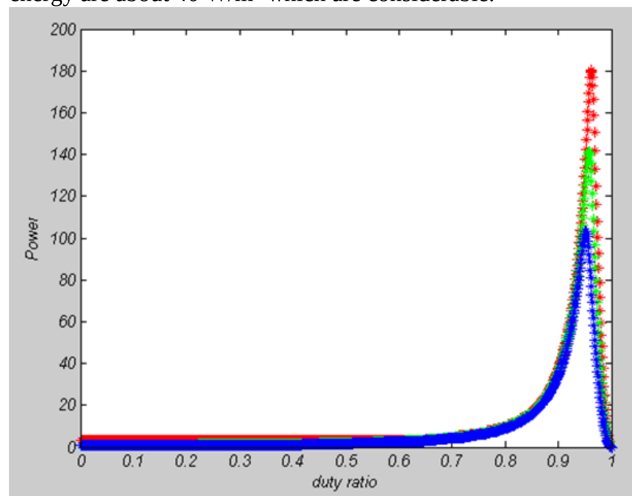

Figure 12. Assessment of the variable condition in day cycle

7. Conclusion

Solar energy is considered as cheapest and cleanest energy source for the environment due of the Iran's geographic and geological conditions. Its implementation will always be accompanied by functional and operational success. In this study, day-night variations have been considered for evaluate the energy dissipation because of the main and repeatedly affect on solar panels on this case. For this purpose, two group simulations based on the particle swarm optimization (PSO) and perturb & observe (P&O) algorithms is conducted for calculation of radiation effects and energy dissipation quantifications were utilized in MATLAB software. According to the results of the simulations, differences between the constant condition and nigh loss energy are about 40 W/m^2 and day-night cycles is 80 W/m^2 which are considerable.

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