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Effects of Atmospheric Changes on Reducing the Performance of Solar Panels by Particle Swarm Optimization Algorithm

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ABSTRACT

Solar energy as the most important source of renewable energy is an important alternative to fossil and non-renewable energies. This energy source, in addition to many benefits, is also very sensitive to environmental changes. Atmospheric changes can be expressed as a main factor in reducing the performance of Solar Cells. In this study, by using particle swarm optimization algorithm, the amount of solar energy dissipation in solar panels affected by atmospheric changes (the most important factor), including radiation, precipitation and wind, has been investigated. For this purpose, a comparative method with the base state has been used and the amount of difference between the two results in the solar cells is measured. In this regard, created solar cells in Maragheh city are considered as the basis for analysis. Based on the results of measurements and simulation by particle swarm optimization algorithm, the maximum atmospheric effect is related to the variations curve of the precipitation and then the variations curve of the radiation (shadow). Also, wind changes have had the least impact on reducing the performance of solar panels in the area.

1. Introduction

Fossil fuels have been always known as the desolator of the environment because they are non- renewal and costly and they have very adverse effects on the environment. For this purpose, in recent decades, there have been attempts to find or create Suitable alternatives for energy sources. Among alternative energy sources, solar energy is an optimal option. Solar energy is widely used in different countries around the world because of limited environmental problems and the implementing more easily than other energy supplies (Villalva et al., 2009). This energy is used in 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 1839, a French experimental physicist, Edmund Becquerel, discovered the creation of a weak electrical current when he put some material in front of the sun (Jieming et al., 2013). According to growing the global demand for electricity and increasing the need to track the global challenges of global energy security, climate changes and sustainable development, a significant amount of research effort has been made on the development of PV cells, which are basically semiconductors that can directly convert light into electricity with PV effect. Because of that the output power of the PV cells is limited at high voltage levels, The PV unit, which is a collection of PV cells, is commonly used as a primary component in large PV systems. Today's technology of PV is more complex than ever, Types of silicon materials have been investigated to increase the energy conversion efficiency and

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reduce the production costs. The PV technology can be grouped into two categories: Silicone Crystal (C-Si) and Thin Factor (TF). The efficiency of converting PV units made from C-Si is around 13-20%, while the efficiency of PV units made from TF is around 6-12% (Seyed-mahmoudian et al., 2013). TF technologies use a small amount of active materials that can be produced at a lower cost than C-Si (Patel and Agarwal, 2008). Recently, many emerging technologies and new PVs such as centralized photovoltaics (CPV), organic solar cells, inorganic TFs, thermal photovoltaics (TPVs) are currently under investigation. PV markets are expanding with the advancement of PV technologies (Wang and Singh, 2007; Soufi et al., 2017).

As it is known, according to the geographical location of each point of the planet, the heating efficiency or energy production of these cells in different seasons of the year is different, and geological factors such as atmospheric conditions, topography, land morphology and latitude have a direct impact on it (Hernandez et al., 2014). However, according to the economic justification of solar energy projects compared with other types of energy, such as fossil fuels or new energies, the use of them in the world is increased dramatically. One of the benefits of solar systems is the use of an endless and cheap solar energy source, and unlike fossil fuels, these systems are not created a risk for the environment, and heating the needed water, heating the building's space or hotel, has no cost for many years. Figure 1 shows an overview of the use of solar energy by solar panels in recent years. As seen in this figure, over a period of ten years only, the use of solar panels to provide clean energies has reached over 900 megawatts (Eseye et al., 2018). Iran because of the geographical location (in the range of 25 to 40 degrees north latitude), it is located in an area that is in a high standard in terms of receiving solar energy from around the world. The average solar radiation in Iran is estimated to be between 4.5 and 5.5 kWh per square meter per day, which is, of course, above the global average.

In Iran, 220 sunny days has been reported in a year annually, which it is very noticeable (Sarparast et al., 2013), and the use of this energy for the country is very suitable and successful. However, the use of solar cells equipment and supplies requires some conditions that must be considered during location allocation, design, construction, and construction after construction (Salam et al., 2013). The vast areas of the plain (without relief) without massive vegetation and the continuous exposure of sunlight with the appropriate radiation angle is the most important principle in the implementation of solar energy supply facilities (Ram et al., 2017).

On the other hand, the construction of this facility has caused environmental changes in the area that will have a common impact on land operations. These effects include changes in the amount and concentration of greenhouse gases, changes in the temperature of the earth's surface and atmospheric boundary conditions, changes in the micro-fluidity and atmospheric conditions of the region, changes in the rainfall-evaporation regime, erosion, dust generation, and the creation of micro-organisms, the impact of Albedo, desertification, noise, pollution, surface/subsurface water pollution and soil contamination (Hernandez et al., 2014). Each of these environmental issues can be controlled and reduced by implementing optimization and stabilization methods (Naddafi et al., 2012).

In this study, atmospheric variations have been considered because they have huge influence on solar panels. Rainfall, changes in the conditions of radiation (shadow) and wind affect the efficiency of work and its energy production due to disruption of solar panel operation where an optimized approach was carried out to evaluate the climate change in measuring the performance of solar panels, and was studied in Maragheh.

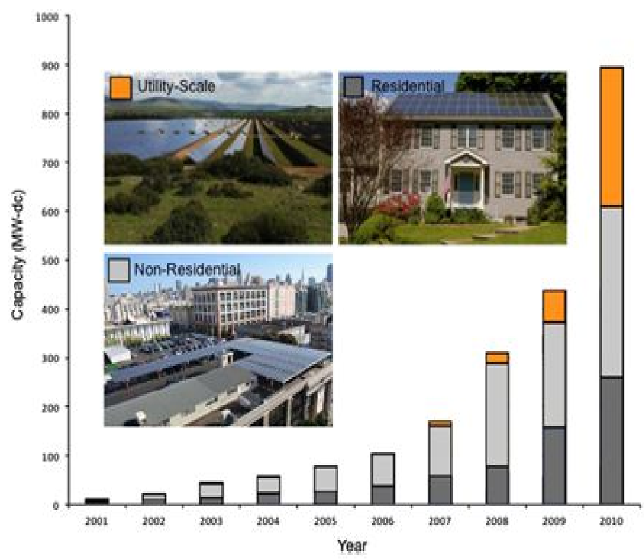

Figure. 1. The Status of Using Solar Panels in Clean Energy Supply (Sherwood, 2012)

2. Study area

Maragheh is the second largest city in the east-Azerbaijan province and it is special administrative center of Maragheh county which is located along the Sufi-chay River on the southern of Sahand Mount and 135 kilometers south of the provincial capital (Tabriz). This city is located in the eastern part of Urmia Lake 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).

This city has an area of 2647 hectares and is located in alluvial of the Sufi-chay River. The climate of Maragheh is mild, cold and relatively humid. The maximum temperature of this city in the summer is about 35oC and in winter it is about 20oC 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 2 shows the geographic location and geological conditions of Maragheh in Iran. This region is seismically active and it is among the earthquake areas of the country. The passage of stranded and alluvial faults with various seismic activities (with different magnitudes) indicates the activity of the region.

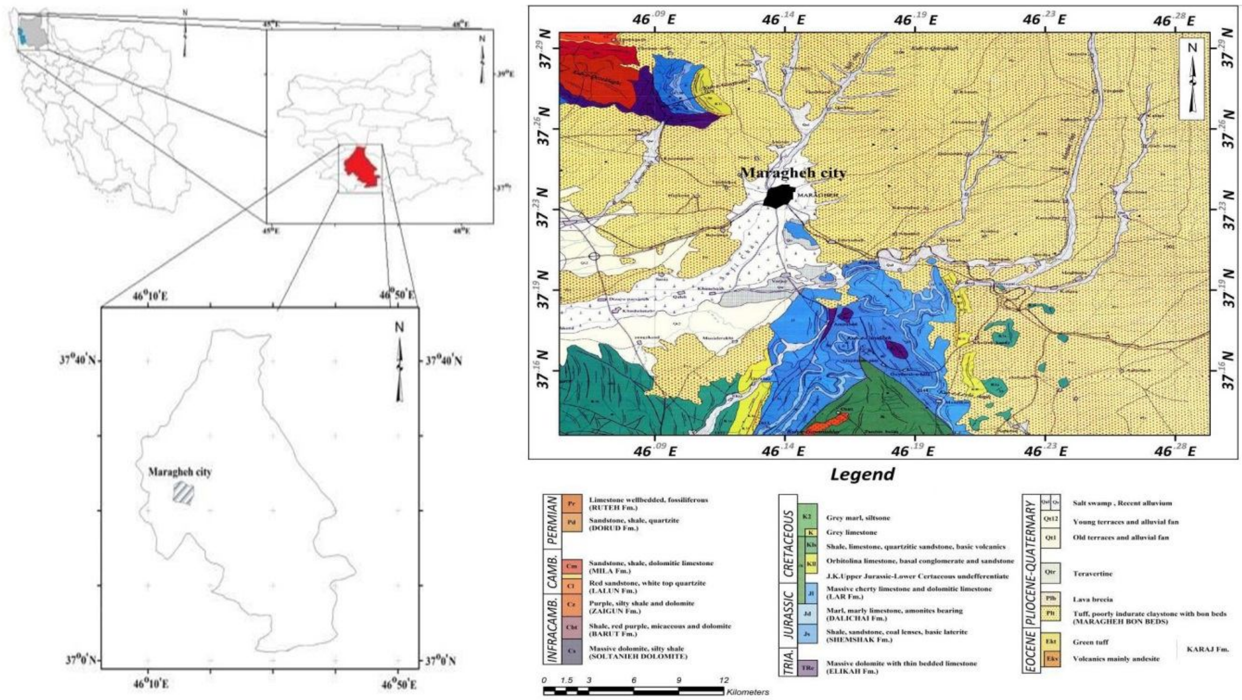

Figure. 2. The geological map and location of Maragheh city (Nikoobakht et al., 2018)

3. Methodology

Producing the electricity by solar panels can be seen as an energy generator to answer the future needs. However, solar panels can do this without creating much noise, Toxic gases or greenhouse gases (Hernandez et al., 2014). In this subject the goal can be considered as maximizing the energy output of a given panel device. However, because of the different atmospheric conditions, such as temperature T and radiation G, the power output of a typical PV cell or module can be changed as a factor (Tajuddin et al., 2013). In addition, all or some parts of the PV system may be placed in the shadow of the trees or they are influenced by passing clouds, high buildings, etc. (called "partial simulation conditions"). Under these conditions, tracking the time may change quickly. These environmental conditions impose additional challenges for parameter estimation and maximum power. The maximum power point tracking (MPPT) algorithm generates a unique non-linear I-V relationship. Existing MPPT algorithms are capable of detecting the operating point, especially in the non-uniform solar radiation level. However, they are weakened in shadow conditions. In this situation, optimization algorithms can be used.

The used algorithm in this study is particle swarm optimization (PSO) algorithm. The PSO algorithm is a global minimization method that can be used to solve problems that their answer is a point or a surface in the n-dimensional space. The PSO algorithm is a 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 disturbance and observation (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 (dP/dV). Figure 3 shows three points in different positions. A point in the peak curve ($dP/dV=0$) can be attributed to MPP. While a point on the left of the MPP ($dP/dV>0$) means that the power change to the voltage change is greater than zero. However, the opposite position, located to the right of the MPP ($dP/dV<0$), is the power change to change the voltage below zero. If the voltage is disrupted and dipped to the left ($dP/dV>0$) then the disturbance to transmit the forward voltage is close to the MPP. Meanwhile, point-of-time changes are diverted from MPP, which is $dP/dV<0$. Then the P&O method will reverse the disturbance. This mechanism is shown in the flowchart of Figure 4. P&O method is usually used for its simplicity. In addition, it is possible to provide improvements in the implementation. However, this method disadvantage is that not beneficial under radiation degradation (Miyatake et al., 2011).

As shown in Figure 5, there are three P-V curves that have different solar radiation. Each of them has a higher range of curves 1, curve 2 and curve 3, respectively. In these statuses, the operating voltage initially fluctuates around the MPP point from point B to A at curve 1. If the radiation changes suddenly, it creates a point that should be transmitted to curve 2. During that process, assuming the operating point, the disturbance from point A to B would occur at point D. Disruption in the same direction will continue until there is a positive increase in power. It will continue to the point F and will be transferred to point G in curve 3 and will continue to disrupt Point I (Yang et al., 2012).

The phenomenon of point movement (from points A through D to G) indicates that the powers are lower, which means reducing the effectiveness. So this could be a weakness of method. Furthermore, it also has a fault in the flat Curve tendency. When the amount of sunlight is limited, it's difficult to determine the MPP point. The MPPT provides an V_{erf} for building operational points which can be at the V_{mpp} point and then reaches the MPP point. MPP searches can also be done using the dI/dV equation (Yang et al., 2012).

$$\frac{dP}{dV} = 0 \quad \text{PV in the MPP curve (Basic point)} \tag{1}$$

Since P=V.I, then (Yang et al., 2012):

$$\frac{d(V.I)}{dV} = \frac{V.dI + dV.I}{dV} \tag{2}$$

$$V\frac{dI}{dV} + I = 0 \tag{3}$$

So that:

$$\frac{dI}{dV} = -\frac{I}{V} \quad \text{in the MPP point} \tag{4}$$

$$\frac{dI}{dV} > -\frac{I}{V} \quad \text{in the left of the MPP point} \tag{5}$$

$$\frac{dI}{dV} < -\frac{I}{V} \quad \text{in the right of the MPP point} \tag{6}$$

If the operating voltage point is in MPP, it means that dI/dV=-I/V. When the operating voltage point is to the left of the MPP point, dI/dV>-I/V. Otherwise dI/dV<-I/V if the operating voltage point is located to the right of the MPP point (Fig. 3). In this case, Eq. 4 expresses the incremental transfer ratio (left) and Immediate transfer (right). The MPP can be tracked by comparing both of them in the flowchart shown in Fig. 4. This method has been developed to overcome the dependence of P&O on atmospheric conditions, especially in solar radiation that is changing rapidly. Also, it has less oscillation around MPP than P&O method (Yang et al., 2012). However, the inductance method requires a complicated control circuit. At the time of data implementation, two categories of base model (simulated in ideal conditions) and atmospheric variation models (main variables (shadow), rainfall and wind) have been prepared. Final results are comprehensively estimated for each modes of the Maragheh city and simulated by MATLAB (Atallah et al., 2014; Ram and Rajasekar, 2017; Babu et al., 2018).

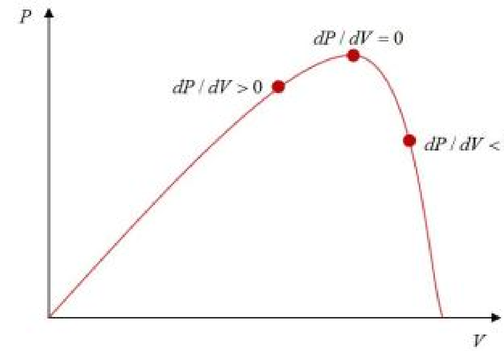

Figure. 3. The dP/dV positions in the P-V curve (Patel and Agarwal, 2008)

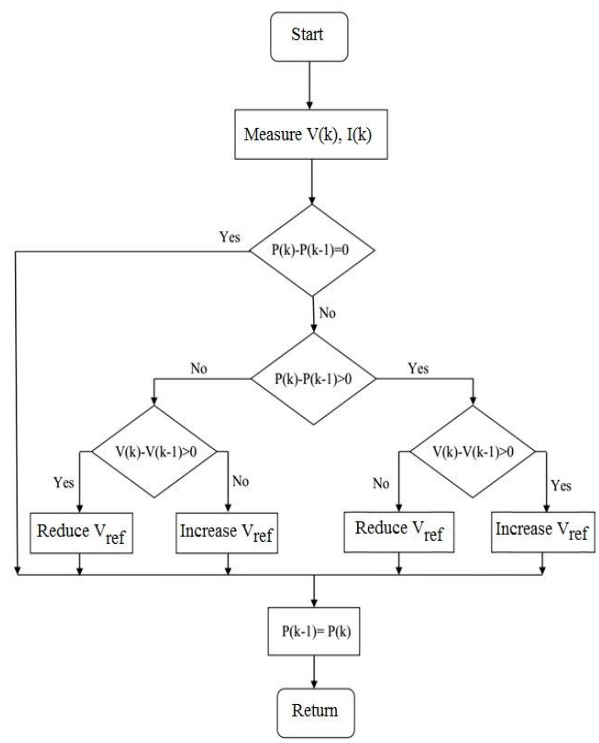

Figure. 4. P&O flowchart (Rezk and Eltamaly, 2015)

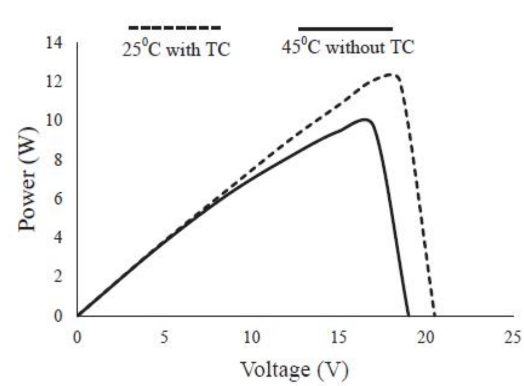

Figure. 5. P-V curves of solar PV panel at different temperatures (Shahid et al., 2018)

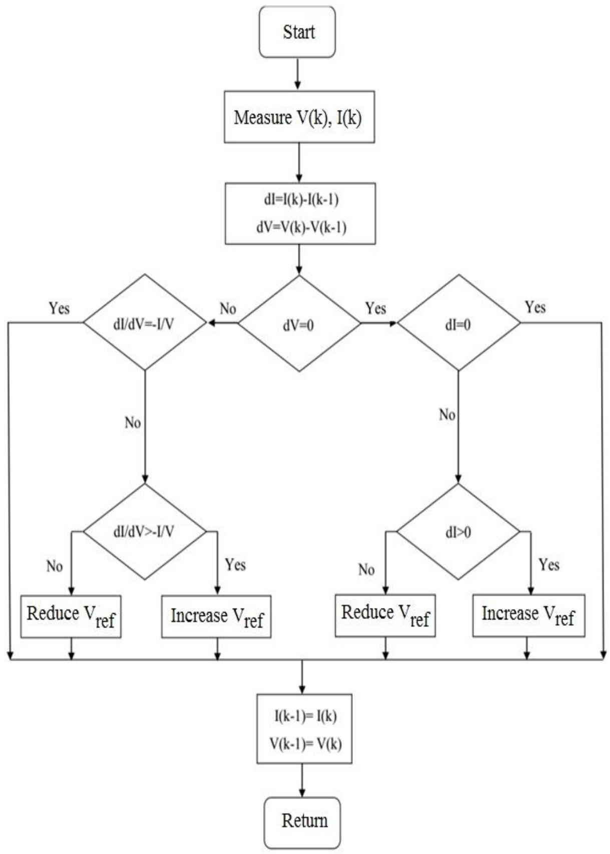

Figure. 6. The ΔI/ΔV positions in relation between the P-V curve and the P-I curve (Putri et al., 2015)

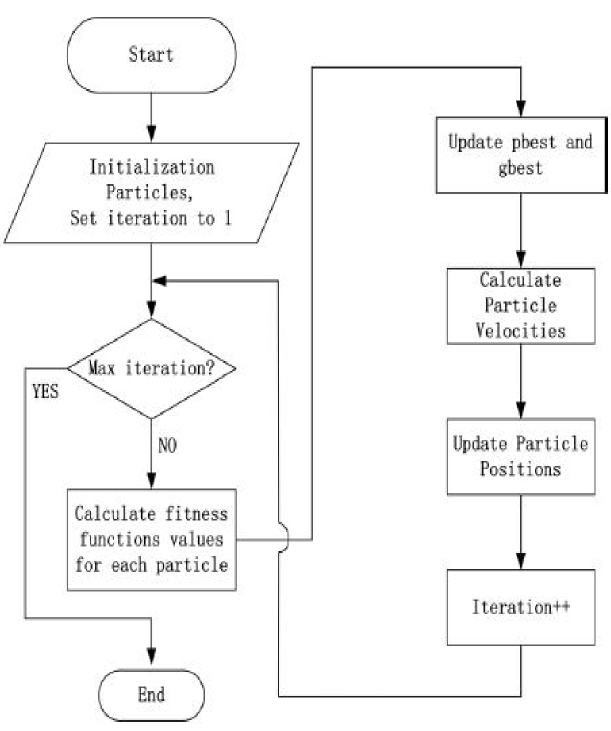

Figure. 7. PSO flowchart (Qin and Kimball, 2011)

4. Results and Discussion

In order to evaluate the results of effects of atmospheric changes on the performance of solar panels, two groups of modeling have been carried out. The first group is called base simulation that is for the purpose of comparative evaluation of atmospheric variation. The second group is a functional change that is caused by atmospheric changes and is determined by random changes on the panels. Based on simulation results, the PV 200 panel is used in base mode that open circuit voltage is 35.5 V and the short circuit current is 82.7 amps. In this simulation, the default temperature is 308°K or 35°C. Also, the default solar radiation is 21000 W/m^2, in addition to the randomized solar randomized list. In addition, for other features, the Tr or the temperature of the source cell is 298°K. Short circuit current temperature coefficient (K_o) is 6×10-4, connection ideal factor (A) is 18, number of cells (N) is 6, electron load is 1.6×10-19, Boltzmann's constant is 1.38×1023, and the energy of the semi-conducting band gap used in the cell is 6 EV.

Figure 8 presents the simulation process in two groups. Also, Figure 9 and Table 1 show the results of baseline simulation based on recorded data. By setting the time, the randomized solar radiation reported for data from 17 to 8 is a total of 10 hours (one hour is 3600 seconds, and this group takes points every 10 seconds, so there are 180 randomized solar radiation recorded per hour).The most important atmospheric variables related to solar panel operation are radiation (shadow), rainfall and wind. For this purpose, in the joint period with the first group, individual variables that are considered randomly and independently have been evaluated. The results of the variations of these variables are presented in Figs. 10 to 12 and in Table 2.

If parameters of the particle swarm algorithm are considered without model and only by initializing the parameters by collected data set, these data with one repeat can be accessed by an algorithm. Given the optimization of the nature of the algorithm, the used algorithm will try to improve the maximum power point. Therefore, the amounts of differences are normalized by eliminating errors and computational deviations.

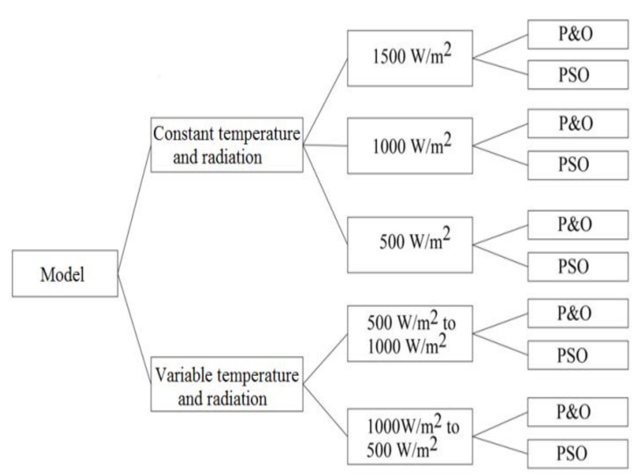

Figure. 8. Process of modeling in different groups

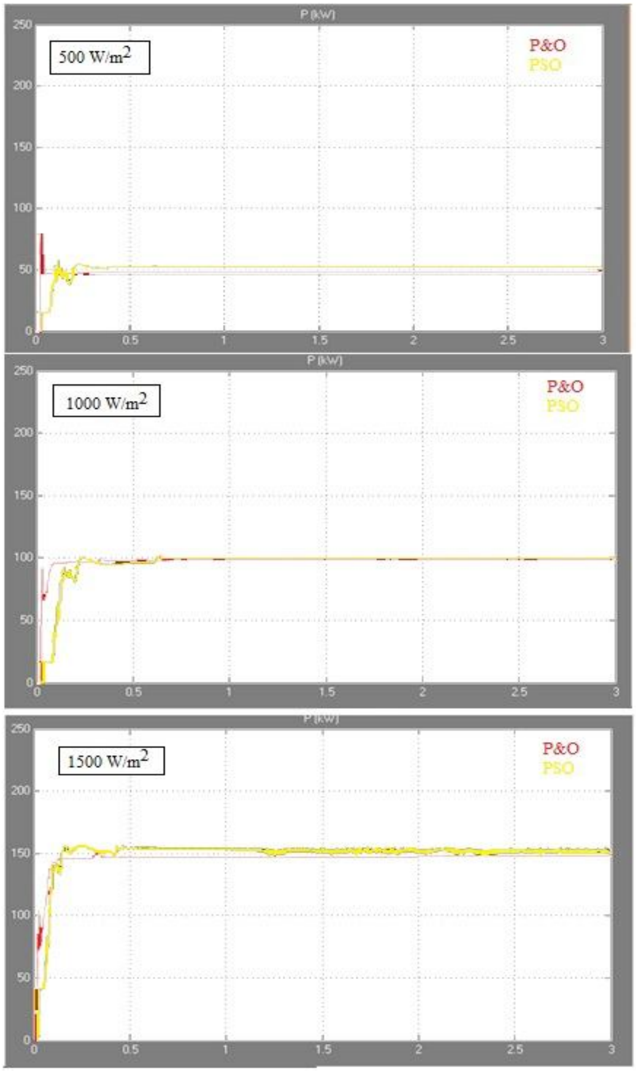

Figure. 9. The results of solar panels performance for constant atmospheric conditions

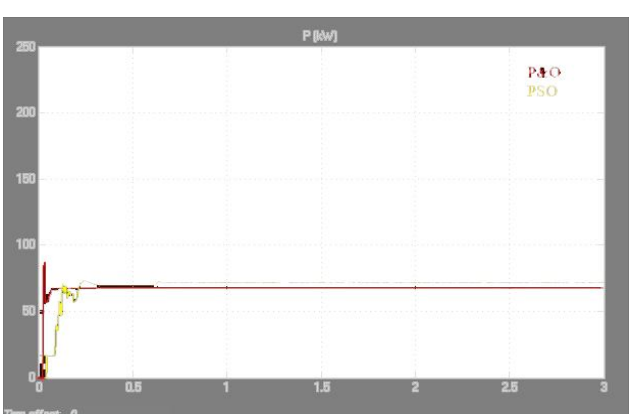

Figure. 10. Results of solar panels performance for atmospheric radiation variable

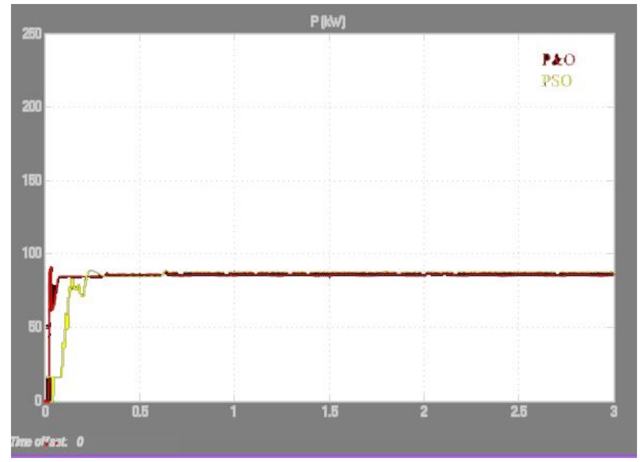

Figure. 11. Results of solar panels performance for atmospheric rain variable

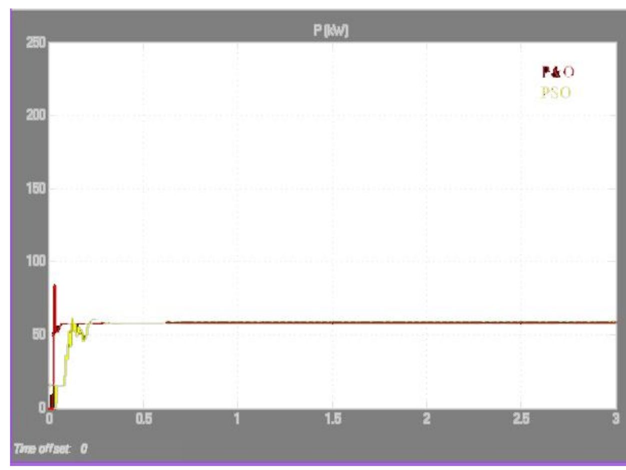

Figure. 12. Results of solar panels performance for atmospheric wind variable

Table 1 Single radiation result for constant atmospheric conditions

Solar energy (W/m^2)	P&Q		PSO	
	Tracking power time (KW)	Obtained energy (KJ)	Tracking power time (KW)	Obtained energy (KJ)
1500	148.71	202.32	150.4	189.56
1000	98.52	157.41	99.53	128.00
500	47.40	87.40	44.51	79.56

Table 2 Single radiation result for variable atmospheric conditions

Solar energy (W/m^2)	P&Q		PSO	
	Tracking power time (KW)	Obtained energy (KJ)	Tracking power time (KW)	Obtained energy (KJ)
Radiation	69.04	80.91	71.164	76.6
Rain	60.6	101.44	68.14	97.7
Wind	74.41	65.2	78.90	61.315

5. Conclusion

Solar energy is the cheapest and cleanest source of energy for the environment because of the geographic and geological conditions of Iran; its implementation will always be accompanied by functional and operational success. The performance of these panels is directly dependent on various environmental changes and it can change (decrease or increase) their efficiency. These effects include changes in greenhouse gases density, temperature changes in earth's surface and atmospheric conditions, micro-fluidity changes and region atmospheric conditions, rainfall-evaporation regime changes, erosion, dust generation, micro-organisms creation, the Albedo impact, desertification changes, noise and light pollution, surface/subsurface water pollutions and soil pollution. In this study, atmospheric variations have been considered because of the huge influence on solar panels in this study. Rainfall, radiation conditions (shadow) changes and wind is affected the energy production and disrupting the solar panels are comprehensively estimated. In this study, using the particle algorithm, the solar energy dissipation in solar panels affected by atmospheric changes (as most important factor), including radiation (shadow), precipitation and wind, has been investigated. For this purpose, the comparative approach with the base case is used and the difference between the two results in the solar cell is measured. In this regard, solar panels implemented in Maragheh are considered as the basis for the analysis. Based on the results of measurements and simulation by the particle algorithm, the most atmospheric effect is on the rainfall curve and then the radiation. Wind changes have had the least impact on reducing the performance of solar panels in the area.

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References

Agha-Nabati A. (2007). *Geology of Iran*. Geological Survey of Iran press, Tehran, Iran. [In Persian]

Atallah A.M., Abdelaziz Y.A., Jumaahi R.S. (2014). Implementation of perturb and observe MPPT of PV system with direct control method using buck and buck-boost conveters. *Emerging Trends in Electrical, Electronics & Instrumentation Engineering: An International Journal*, 1(1): 31-44.

Azarafza M., Mokhtari M.H. (2013). Evaluation drought effect on the Urmia lake salinity change by using remote sensing techniques, *Arid Biome Scientific and Research Journal*, 3(2): 1-14.

Babu T.S., Ram J.P., Dragičević T., Miyatake M., Blaabjerg F., Rajasekar N. (2018). Particle Swarm Optimization Based Solar PV Array Reconfiguration of the Maximum Power Extraction Under Partial Shading Conditions. *IEEE Transactions on Sustainable Energy*, 9(1): 74-85.

Eseye A., Zhang J., Zheng D. (2018). Short-term photovoltaic solar power forecasting using a hybrid Wavelet-PSO-SVM model based on SCADA and Meteorological information. *Renewable Energy*, 188: 357-367.

Hernandez R.R., Easter S.B., Murphy-Mariscal M.I., Maestre F.T., Tavassoli M., Allen E.B., Barrows C.W., Belnap J., Ochoa-Hueso R., Ravi S., Allen M.F. (2014). Environmental impacts of utility-scale solar energy. *Renewable and Sustainable Energy Reviews*, 29: 766-779.

Jieming M., Man K.L., Ting T.O., Zhang N., Lei C., Wong N. (2013). Low-cost global mppt scheme for photovoltaic systems under partially shadedconditions. I*EEE International Symposium on Circuits and Systems (ISCAS)*, 24: 245-248.

Miyatake M., Veerachary M., Toriumi F., Fujii N., Ko H. (2011). Maximum power point tracking of multiple photovoltaic arrays: A pso approach. *IEEE Transactions on Aerospace and Electronic Systems*, 47(1): 367-380.

Naddafi K., Hassanvand M.S., Yunesian M., Momeniha F., Nabizadeh R., Faridi S. (2012). Health impact assessment of air pollution in megacity of Tehran, Iran. *Iranian Journal of Environmental Health Science & Engineering*, 9(1): 28.

Nemet G.F. (2009). Net radiative forcing from widespread deployment of photovoltaics. *Environmental Science & Technology*, 43(6): 2173-2178.

Nikoobakht S., Azarafza M., Safaei H. (2018). Estimation of Seismicity Parameters and Hazard Assessment of Maragheh City, Iran. *Çankaya University Journal of Science and Engineering*, 15(1): 001-022.

Patel H., Agarwal V. (2008). Maximum power point tracking scheme for pv system soperating under partially shaded conditions. *IEEE Transactions on Industrial Electronics*, 55(4): 1689-1698.

Putri R.I., Wibowo S., Rifâi, M. (2015). Maximum power point tracking for photovoltaic using incremental conductance method. *Energy Procedia*, 68: 22-30.

Qin H., Kimball J.W. (2011). Parameter determination of Photovoltaic Cells from field testing data using particle swarm optimization. In: *Proceedings of the 2011 IEEE Power and Energy Conference*, Illinois, DOI: 10.1109/PECI.2011.5740496.

Ram J.P., Babu T.S., Rajasekar N. (2017). A comprehensive review on solar PV maximum power point tracking techniques. *Renewable and Sustainable Energy Reviews*, 67: 826-847.

Ram J.P., Rajasekar N. (2017). A new global maximum power point tracking technique for solar photovoltaic (PV) system under partial shading conditions (PSC). *Energy*, 118(1): 512-525.

Rezk H., Eltamaly A.M. (2015). A comprehensive comparison of different MPPT techniques for photovoltaic systems. *Solar energy*, 112: 1-11.

Salam Z., Ahmed J., Merugu B.S. (2013). The application of soft computing methods for MPPT of PV system: A technological and status review. *Applied Energy*, 107: 135-148.

Sarparast M., Hesam M., Asgari H.R. (2013). Determining Appropriate Provinces for Dew Harvesting in Iran. *International Journal of Environmental Resource Research*, 2(1): 21-30.

Seyed-mahmoudian M., Mekhilef S. Rahmani R., Rubiya Y., Renani E. (2013). Analytical modeling of partially shaded photovoltaic systems. *Energies*, 6(1): 128-144.

Shahid H., Kamran M., Mehmood Z., Saleem M.Y., Mudassar M., Haider K. (2018). Implementation of the novel temperature controller and incremental conductance MPPT algorithm for indoor photovoltaic system. *Solar Energy*, 163: 235-242.

Sharma N.K., Tiwari P.K., Sood Y.R. (2012). Solarenergy in India: strategies, policies perspectives, and future potential. *Renewable and Sustainable Energy Reviews*, 16(1):933-941.

Sherwood L. (2012). *U.S. Solar Market Trends 2011*. Interstate Renewable Energy Council, Inc. Available at (http://www.irecusa.org/wp-content/uploads/IRECSolarMarketTrends-2012-Web-8-28-12.pdf).

Soufi Y., Bechouat M., Kahla S. (2017). Fuzzy-PSO controller design for maximum power point tracking in photovoltaic system. *International Journal of Hydrogen Energy*, 42(13): 8680-8688.

Tajuddin M.F.N., Ayob S.M., Salam Z., Saad M.S. (2013). Evolutionary based maximum power point tracking technique using dierential evolution algorithm. *Energy and Buildings*, 67(3): 245-252.

Veerachary M., Senjyu T., Uezato K. (2002). Voltage based maximum power point tracking control of PV system. *IEEE Transactions on Aerospace and Electronic Systems*, 38(1): 262-270.

Villalva M.G., Gazoli J.R., Filho E.R. (2009). Comprehensive approach to modeling and simulation of photovoltaic arrays. *IEEE Transactions on Power Electronics*, 24(5): 1198-1208.

Wang L., Singh C. (2007). PSO-Based Multi-Criteria Optimum Design of A Grid-Connected Hybrid Power System With Multiple Renewable Sources of Energy. In: *Proceedings of the 2007 IEEE Swarm Intelligence Symposium*, DOI: 10.1109/SI S.2007.367945.

Yang X.S., Deb S., Fong S., (2012). Accelerated Particle Swarm Optimization and Support Vector Machine for Business Optimization and Applications. *Optimization and Control*, CCIS 136: 53-66.