Indian Journal of Fundamental and Applied Life Sciences ISSN: 2231– 6345 (Online)
An Open Access, Online International Journal Available at www.cibtech.org/sp.ed/jls/2014/03/jls.htm
2014 Vol. 4 (S3), pp. 1729-1734/Rezaei et al.
Research Article

INVESTIGATING THE EFFECT OF ENVIRONMENTAL FACTORS ON THE PERFORMANCE OF SOLAR ARRAYS (A CASE STUDY OF SHIRAZ CITY)

[*]Ali Rezaei[1], Sobhan Dorahaki[1], Sajad Houshmand[2] and Abbas Rezaei[3]
[1]Young Researchers and Elite Club, Bushehr Branch, Islamic Azad University, Bushehr, Iran
[2]Department of Electrical Power Engineering, Islamic Azad University of Bushehr Branch
[3]Department of Mechanical Engineering, Jahrom University
**Author for Correspondence*

ABSTRACT
The paper examines the effects of radiation and temperature on photovoltaic systems in environmental conditions of Shiraz City. In this regard, first the Circuit model of photo voltaic array is evaluated. After reviewing the case and obtaining climate data using the RET Screen software, and simulating the results in MATLAB software, we concluded that with increase of radiation, the maximum power increases in the area. Then, temperature reducing effect on power, as well as radiation increasing effect on power was surveyed. The findings of the study can be useful to design a solar power plant in the area.

Keywords: *Photovoltaic, Shiraz, Simulink, Radiation, Temperature*

INTRODUCTION
Excessive use of fossil fuels during the last century has led to the increase of environmental pollution in the world; consequently researchers are looking for clean and renewable energy sources. Among proposed energies, such as wind power, solar farms, wave energy, geothermal, photovoltaic and etc. Photo voltaic energy takes the priority, because of being renewable and non-polluting.
Due to the high costs of setting up photovoltaic power plants to know environmental factors affecting optimal performance of these systems is priceless (Dorahaki *et al.*, 2014) .In this regard, among the affecting factors including humidity, air pressure, wind speed, shadowing, radiation, temperature, and etc. solar radiation and temperature factors have the greatest impacts. Hence, many studies are conducted regarding these factors. Asgrany *et al.*, (2013), in an article titled "Presenting a new method for tracking maximum power point in solar arrays used in Satellite Electrical Power Systems" argued that the efficiency of solar cells decreases with increase of temperature (Asgrany *et al.*, 2013). Geographic area surveyed in the study (Shiraz) is one of the temperate regions of the country. In this area, there is a convenient solar irradiance during most seasons of the year, and temperature is the only worrying factor, since increase of the temperature decreases the amount of maximum power. Therefore, in this study the effect of temperature and radiation is evaluated to achieve the maximum power in geographical area of Shiraz city.

Modeling Photovoltaic Array
Photovoltaic refers to a process in which sunlight is converted directly into electrical energy. In solar cells which are consisted of semiconductors such as silicon, when P_N bonds are exposed to light, the energy of light photons would be absorbed into bonds and this increases the energy of its electrons which leads to excitation of electrons into higher energy levels. This process, in turn, leads to generation of energy flow in the solar cells.

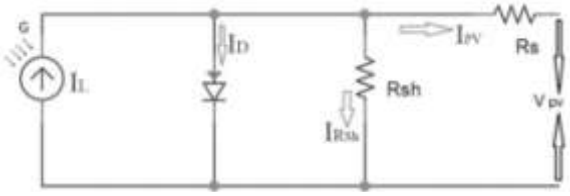

Figure1: Circuit Model of Solar Cells (Patel and Agarval, 2008)

Different models are proposed to achieve an actual model for photovoltaic panels. Among the other models, single-diode model despite being too simple is very close to actual model (Keles *et al.,* 2013). Figure 1 illustrates the circuit model of a solar cell.

The current source I_L models the current produced by sunlight in a solar cell. As we shall see in the next sections, I_V and P_V curves of photovoltaic system are nonlinear to a large extent; the reason of the being nonlinear may be due to diode which is modeled.

Parallel resistance (R_{sh}) models the loss in a solar cell. And since the loss is too low the amount of R_{sh} will be considered too high. It's worth mentioning, that due to the large values of R_{sh} many researchers ignore its effect. In the study, in order to increase the accuracy of calculations, the effect of R_{sh} is considered. Bearing in mind the above mentioned items, equations 1 to 4 are obtained.

Equation (1) represents the output of solar cells (Razzaghi and Mousavi, 2013).

$$I_l = \frac{G}{G_n}(I_{scn} + K_i(T - T_n) \quad (1)$$

Simulating equation (1) in MATLAB Simulink software is as shown in figure 2:

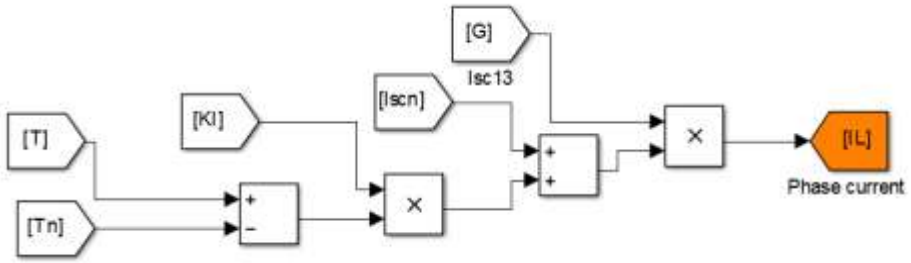

Figure 2: Block Diagram for Simulating Equation (1)

Equation (2) shows the current pass through R_{sh} resistance and the loss rate for solar cells.

$$I_{Rsh} = \frac{V_{pv} + R_s I_{Pv}}{R_{sh}} \quad (2)$$

Simulating equation (2) in MATLAB Simulink software is as shown in figure 3:

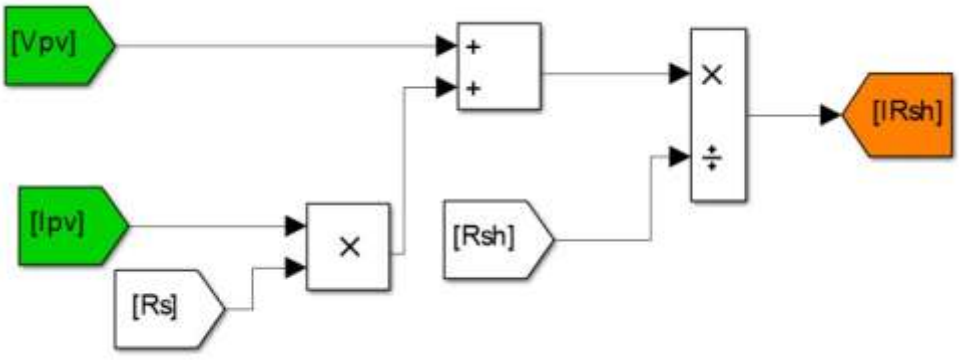

Figure 3: Block Diagram for Simulating Equation (2)

Equation (3) represents the equation of current flowing through the diode.

$$I_D = I_s\left(e^{\frac{V_{pv} + R_s \times I_{pv}}{nKT/q}} - 1\right) \quad (3)$$

Simulating equation (3) in MATLAB Simulink software is as shown in figure 4:

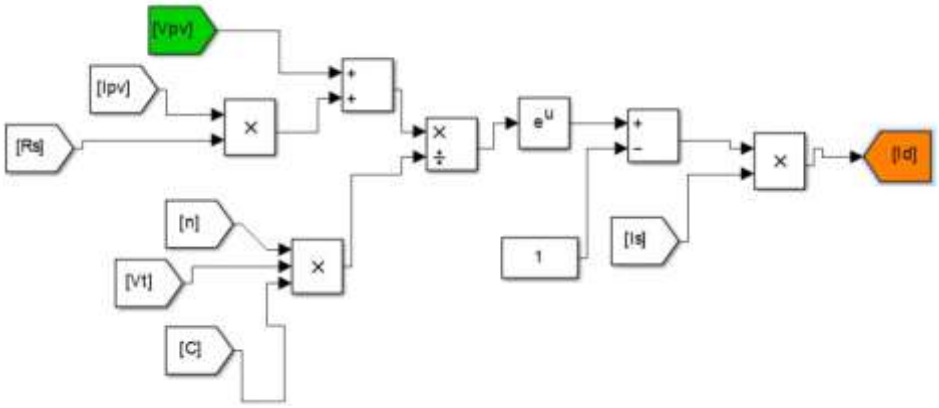

Figure 4: Block Diagram for Simulating Equation (3)

Applying kcl in upper node equation (4) will be achieved.

$$I_{pv} = I_l - I_D - I_{Rsh} \quad (4)$$

Simulating equation (4) in MATLAB Simulink software is as shown in figure 5:

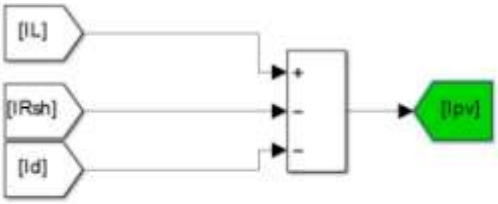

Figure 5: Block Diagram for Simulating Equation (4)

Environmental Conditions in Shiraz City

Shiraz, the center of Fars Province with a length of 40 km and a width varying between 15 and 30 km, with an area of 1268 square kilometers, rectangular shaped and geographically is located in southwest of Iran and in central part of Fars province. Geographic coordinates of Shiraz are 29 degrees 36 minutes north and 52 degrees 32 minutes east and its altitude varies between 1480 to 1670 meters above sea level, in different parts of the city.

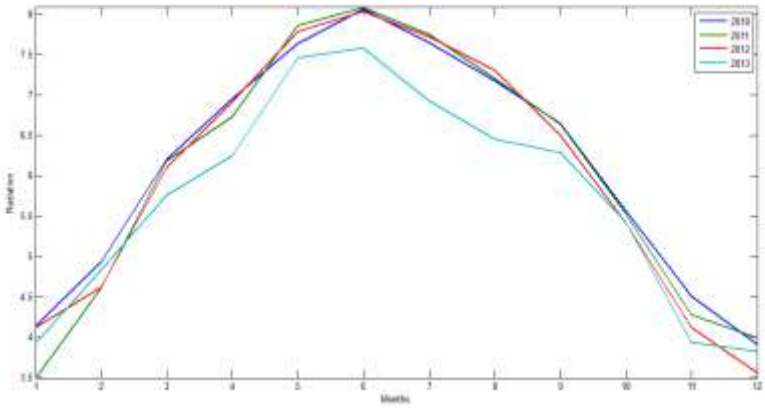

Figure 6: Changes of Solar Radiation for 2010-2013, related to Geographic Location of Shiraz City

In the study, applying RETScreen software (Retscreen Software), the climate data of Shiraz cityare extracted for 2010 through 2013 years and is presented as a monthly average (Annex A & B).

Figure 6 shows variation diagram of solar radiation in geographic region of Shiraz city from 2010 to 2013. As it can be seen in the figure, the maximum radiation occurs in June and the minimum radiation occurs in December.

Figure 7 shows the change in temperature values for 2010 to 2013 in geographic area of Shiraz city. As it can be seen in the figure, the maximum temperature occurs in July and minimum temperature occurs in December.

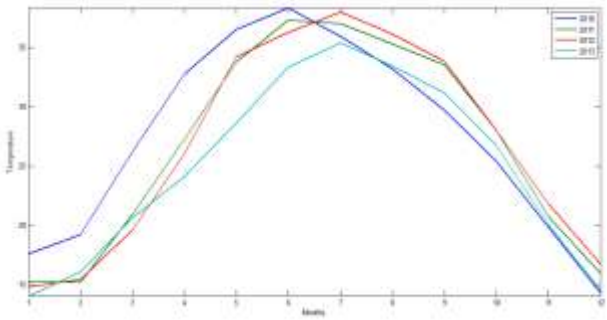

Figure 7: Temperature changes graph for 2010-2013 related to geographic location of the city

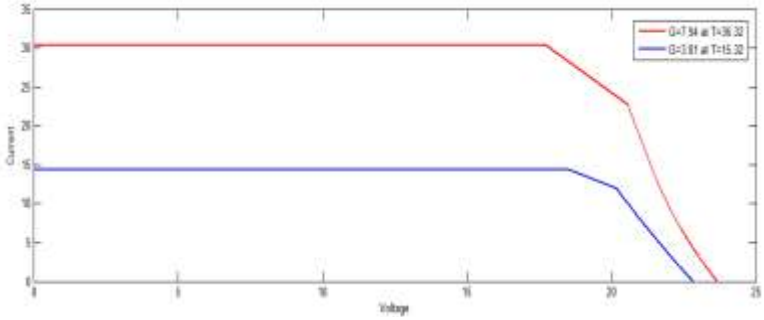

Figure 8: I_V Diagram for minimum and maximum solar radiation and temperature related to months with maximum and minimum solar radiation

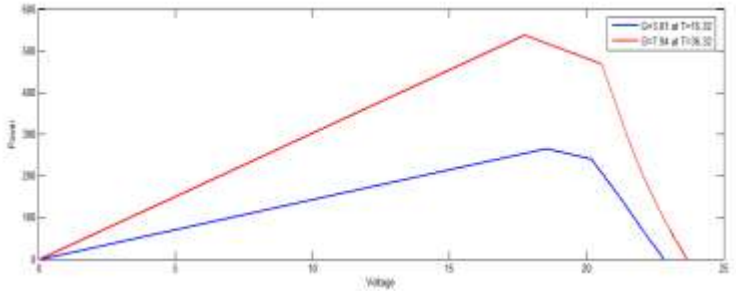

Figure 9: P_V Diagram for minimum and maximum solar radiation and temperature related to months with maximum and minimum solar radiation

The Effect of Radiation and Temperature on Solar Arrays

According to studies carried out by other researchers, increase in radiation leads to increase in produced voltage and output current. Surveys conducted in above mentioned geographic area confirms this effect too. Figure 8shows I_V Diagram, for minimum and maximum solar radiation and temperature, related to the months with maximum and minimum solar radiation. Also, Figure 9 shows P_V diagram for minimum and maximum solar radiation and temperature related to months with maximum and minimum solar radiation.

CONCLUSION

In the present study, first, orbital model of photovoltaic systems and its related relationship was described, and then the relationships were simulated in MATLAB Simulink. Investigating radiation and temperature amounts and providing related diagrams showed that maximum temperature happens in June and July and the minimum temperature happens in December. Simulation shows that increase in solar radiation leads to increase in maximum power. Figures 6 and 7 show, that there is a direct relation between radiation and temperature changes, i.e. during the year when radiation increase, temperature would increase consequently. According to Figures 8 and 9, maximum change occurring in the geographical area has been 295 watts, which is a considerable amount. The findings of the study and presented diagrams can be useful for analysis and feasibility of implementing solar power plant in Shiraz.

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Appendix

Table (A): Radiation Values Related To 2010-2013 in Geographic Region of Shiraz City

2010	2011	2012	2013	Year Month
4.1	3.49	4.11	3.92	**January**
4.9	4.61	4.62	4.83	**February**
6.2	6.18	6.09	5.75	**March**
6.95	6.73	6.91	6.24	**April**
7.64	7.85	7.78	7.46	**May**
8.06	8.08	8.03	7.58	**June**
7.6	7.7	7.72	6.92	**July**
7.18	7.2	7.30	6.44	**August**
6.64	6.63	6.49	6.28	**September**
5.56	5.52	5.41	5.42	**October**
4.5	4.27	4.11	3.92	**November**
3.9	3.9	3.55	3.82	**December**

Table (B): Temperature Values Related To 2010-2013 in Geographic Region of Shiraz City

2010	2011	2012	2013	Year Month
17.6	15.2	14.8	14	**January**
19.2	15.1	15.4	16.02	**February**
26.2	20.9	19.6	20.62	**March**
32.7	27.2	26	24.11	**April**
36.5	33.8	34.2	28.64	**May**
38.38	37.32	36.27	33.32	**June**
35.9	37	37.9	35.42	**July**
33.2	35.3	36.16	33.46	**August**
29.7	33.5	33.84	31.17	**September**
25.3	28	27.98	26.73	**October**
19.8	20.7	21.8	20	**November**
14.2	15.9	16.72	14.43	**December**