International Journal of Engineering Research and Technology.
ISSN 0974-3154 Volume 11, Number 11 (2018), pp. 1811-1819

http://www.irphouse.com

Energy Production Evaluation from a Linear Fresnel Reflectors Arrays with Different Array Orientation

Saad S. Alrwashdeh

Mechanical Engineering Department, Faculty of Engineering,
Mutah University, P.O Box 7, Al-Karak 61710 Jordan.

Abstract

Concentrated solar power applications are one of the most effective types of solar energy application, which will form the future of the new energy applications in the world, especially in Jordan. In this work three reflectors arrangements of Fresnel system were investigated to find the best suitable reflectors arrangements in order to extract more energy from the Fresnel system based on using 3D-Energy simulation in Amman-Jordan.

Keywords: Solar power; Reflectors arrangements; Fresnel system

1. INTRODUCTION

Energy is the important and influential problem for Jordan, where more than 95% of Jordan's national income goes to cover the energy bill of Jordan. From this point, finding solutions for the energy problem is Jordan's first strategic objective. The solution starting from using the available resources efficiently or try to find alternatives to traditional sources. Renewable energy Particularly solar energy is the promising candidate as a solution for the energy problem in Jordan.[1-15]. Here it is essential to encourage investment in the sector of renewable energy in Jordan [4, 12, 16-20].

The investment in renewable energy is economically feasible. Here, it should be mentioned that Jordan is a rich country in natural resources for renewable energy and in particular solar energy available in Jordan with a high solar radiation rate compared to different countries in the world. The use of solar energy to produce electricity may be handled in several ways, including direct methods and indirect methods. One of the most famous direct methods is PV systems and many indirect methods including parabolic trough, solar dish, and Fresnel system. The indirect methods depend on the

steam generation then convert the energy of the steam to mechanical work by rotating a turbine followed by rotating a generator finally the electricity is produced as a result [5-10, 20-35].

Many researchers around the world have been interested in producing electrical energy from solar energy through direct and indirect use [36]. Many problems stand in the way of the use of solar energy to produce electricity, including the stability of electricity production in addition to many natural and environmental conditions, as well as technical problems in various solar systems.[37].

Concentrated solar power systems are one of the most important ways to take advantage of solar energy for the purposes of producing electricity and steam production, but these systems limited by many of the problems and obstacles that prevent the best exploitation of solar energy as it depends on the production of steam and then conduct various transformations of energy from thermal to mechanical Etc. [38-47]. At each of these stages, the losses in energy are very large and affect the overall production of the system [8, 12, 48-53].

The process of the arrangement of the reflectors and ways to confront the sun is one of the most important factors affecting the production from the concentrated solar power systems [7, 54-59]. In this study, the 3D-Energy simulation program was used to study the effect of the array orientation on total energy production at Amman-Jordan.

2. SOLAR CALCULATION BRIEF

The process of designing concentrated solar power systems is a very complex process and to be correct, we must start by calculating the value of solar radiation accurately for the target area. It is also very important to calculate the value of the solar radiation falling at a tilt angle on the different surfaces and then calculate the expected energy quantities from these systems [60-66].

The design of solar systems is dependent on the worst day in solar radiation, which is the 10^{th} of December. The mechanism of the calculation depends on the energy produced daily and then monthly to reach the annual values

3. RESULT AND DISCUSSION

Solar radiation defines the amount of radiation falling on the unit area with a unit of W/m. Figure.1 shows a general view of the simulation program used in this study and it can be seen the existence of three Fresnel systems with different reflectors orientation in order to highlight the effect of reflectors arrangement in the process of energy production.

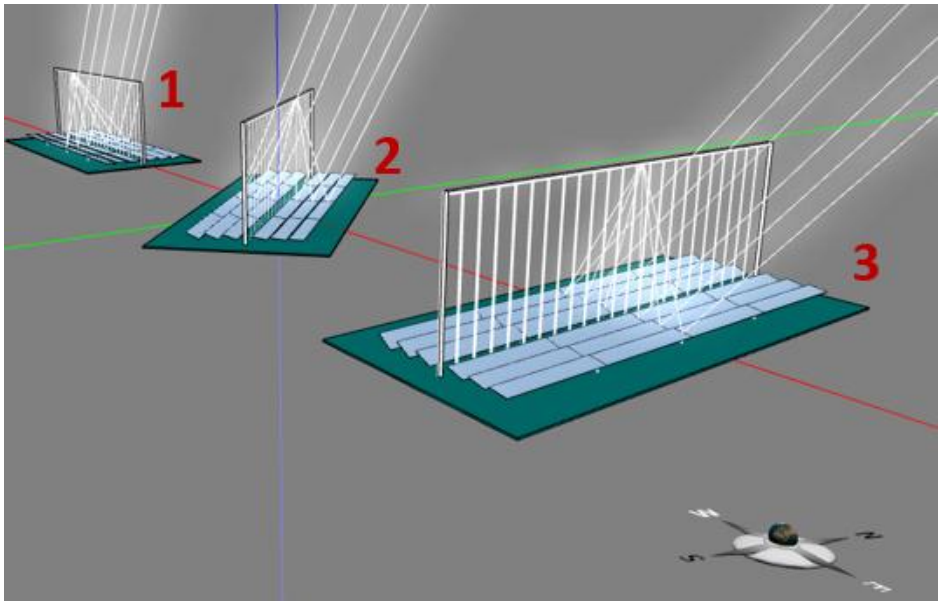

Figure 1. Three Fresnel systems with different reflectors arrangement

Figure. 2 shows the results of the simulation program runs based on the tenth day of each month during the year. It can be noted that the best production of energy was from April till September and the rest of the months of the year is poor in the production and the worst month was December

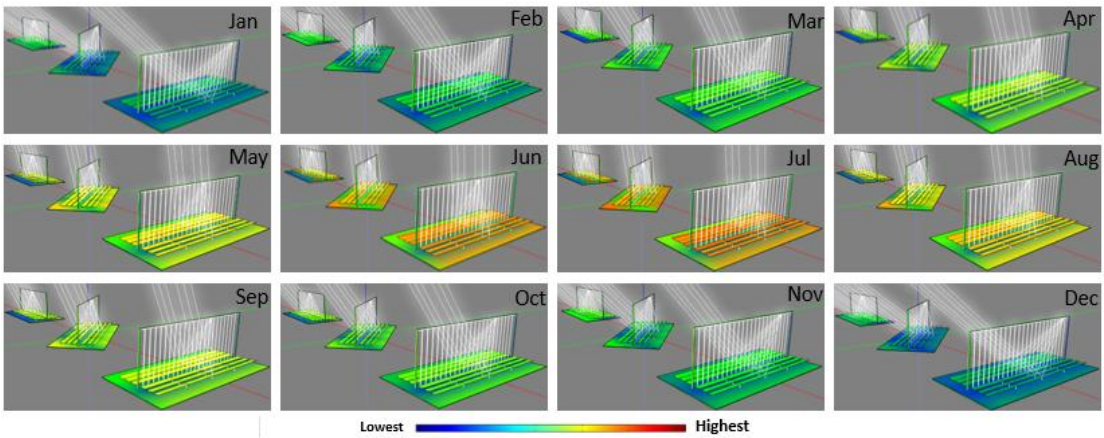

Figure 2. Simulation result of each months of the year

The output power of each system reflectors arrangement was taken separately and then the three systems were compared and the result shows. The first system according to the numbering shown in the first figure produces an energy of 246 kWh while the second system with number 2 produces energy of 228 kWh finally, system number 3 produces energy of 217 kWh.

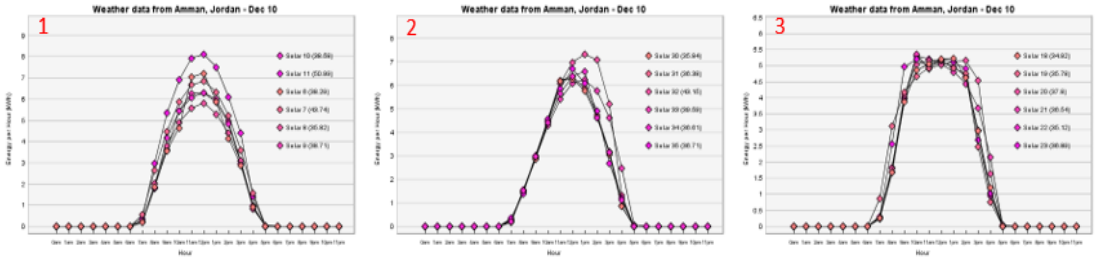

Figure 3. Energy output at 10th of December for the three Fresnel systems with different reflectors arrangement

By evaluating the annual output of energy, it is found that the first system reflectors arrangement produces energy with a value of 175658 kWh/year and the second arrangement system produces energy with the value of 183606 kWh/ year finally, the third arrangement system produces an energy of 189021 kWh/year. From here it is clear that the system with number 3 i.e. the "Third system arrangement" is the best arrangement type for the reflectors to produce energy because it allows the reflectors to face the sun for a better and longer period of time, which helps to increase the production of energy.

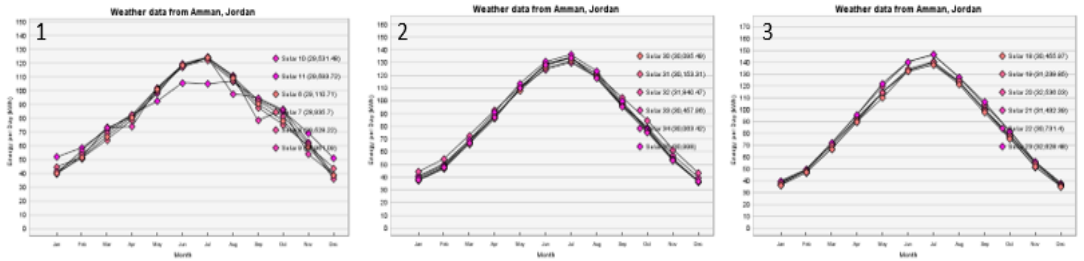

Figure 4. Energy output over the year for the three Fresnel systems with different reflectors arrangement

4. CONCLUSION

The energy production from a three Fresnel systems is studied with Applying different reflectors arrangements: It is found from the result of the simulation that. The max energy output was between April and September. The maximum production was found to be 189021 kWh/year from the third system based on the numbering in Figure.1 while the lowest was for the system with the numbering of 1 with an energy production of 175658 kWh/year

Based on the figure. 2 it is clear that during the spring and summer seasons the energy production will be the maximum and will be the minimum during the winter and autumn. That means the reflectors will face the sun more time during the spring and summer seasons comparing to the winter and autumn.

REFERENCES

1. Alrabie, K. and M.N. Saidan, *A preliminary solar-hydrogen system for Jordan: Impacts assessment and scenarios analysis.* International Journal of Hydrogen Energy, 2018. **43**(19): p. 9211-9223.
2. Hrayshat, E.S. and M.S. Al-Soud, *Solar energy in Jordan: current state and prospects.* Renewable and Sustainable Energy Reviews, 2004. **8**(2): p. 193-200.
3. Frein, A., et al., *Solar DSG plant for pharmaceutical industry in Jordan: Modelling, monitoring and optimization.* Solar Energy, 2018. **173**: p. 362-376.
4. Al-omary, M., M. Kaltschmitt, and C. Becker, *Electricity system in Jordan: Status & prospects.* Renewable and Sustainable Energy Reviews, 2018. **81**: p. 2398-2409.
5. Ammari, H.D., S.S. Al-Rwashdeh, and M.I. Al-Najideen, *Evaluation of wind energy potential and electricity generation at five locations in Jordan.* Sustainable Cities and Society, 2015. **15**: p. 135-143.
6. Handri D.Ammari, S.S.A.-R.a.M.I.A.-N., *Evaluation of wind energy potential and electricity generation at five locations in Jordan.* Sustainable Cities and Society, 2015. **15**: p. 135-143.
7. Alrwashdeh, S.S., *Modelling of Operating Conditions of Conduction Heat Transfer Mode Using Energy 2D Simulation.* International Journal of Online Engineering (iJOE). **14**(9).
8. Alrwashdeh, S.S., *Comparison among Solar Panel Arrays Production with a Different Operating Temperatures in Amman-Jordan.* International Journal of Mechanical Engineering and Technology, 2018. **9**(6): p. 420–429.
9. Ince, U.U., et al., *Effects of compression on water distribution in gas diffusion layer materials of PEMFC in a point injection device by means of synchrotron X-ray imaging.* International Journal of Hydrogen Energy, 2018. **43**(1): p. 391-406.
10. Saad S. Alrwashdeh, F.M.A., Mohammad A. Saraireh, *Solar radiation map of Jordan governorates.* International Journal of Engineering & Technology, 2018. **7**(3).
11. Saad S. Alrwashdeh , F.M.A., *Wind energy production assessment at different sites in Jordan using probability distribution functions.* ARPN Journal of Engineering and Applied Sciences, 2018. **13**(20): p. 8163-8172.
12. Alrwashdeh, s.S., *Investigation of the energy output from PV racks based on using different tracking systems in Amman-Jordan.* International Journal of Mechanical Engineering and Technology, 2018. **9**(10): p. 687–69.
13. Alrwashdeh, S.S., *Investigation of the energy output from PV racks based on using different tracking systems in Amman-Jordan.* International Journal of Mechanical Engineering and Technology, 2018. **9**(10): p. 687–694.

14. Saad S. Alrwashdeh, H.M., Jan Haußmann, Joachim Scholta, André Hilger, Ingo Manke, *X-ray Tomographic Investigation of Water Distribution in Polymer Electrolyte Membrane Fuel Cells with Different Gas Diffusion Media.* ECS Transactions, 2016. **72**(8): p. 99-106.

15. Alrwashdeh, S.S., *Predicting of Energy Production of Solar Tower Based on the Study of the Cosine Efficiency and the Field Layout of Heliostats.* International Journal of Mechanical Engineering and Technology, 2018. **9**(11): p. 250–257.

16. Haagen, M., et al., *Solar Process Steam for Pharmaceutical Industry in Jordan.* Energy Procedia, 2015. **70**: p. 621-625.

17. Al-Ghandoor, A., *Evaluation of energy use in Jordan using energy and exergy analyses.* Energy and Buildings, 2013. **59**: p. 1-10.

18. Jaber, J.O., et al., *Employment of renewable energy in Jordan: Current status, SWOT and problem analysis.* Renewable and Sustainable Energy Reviews, 2015. **49**: p. 490-499.

19. Al-Hamamre, Z., et al., *Assessment of the status and outlook of biomass energy in Jordan.* Energy Conversion and Management, 2014. **77**: p. 183-192.

20. Alrwashdeh, S.S., *Map of Jordan governorates wind distribution and mean power density.* International Journal of Engineering & Technology, 2018. **7**(3): p. 1495-1500.

21. Alawneh, R., et al., *Assessing the contribution of water and energy efficiency in green buildings to achieve United Nations Sustainable Development Goals in Jordan.* Building and Environment, 2018. **146**: p. 119-132.

22. Hrayshat, E.S., *Status and outlook of geothermal energy in Jordan.* Energy for Sustainable Development, 2009. **13**(2): p. 124-128.

23. Al-Ghandoor, A., et al., *Energy and exergy utilizations of the Jordanian SMEs industries.* Energy Conversion and Management, 2013. **65**: p. 682-687.

24. Jaber, J.O., et al., *Renewable energy education in faculties of engineering in Jordan: Relationship between demographics and level of knowledge of senior students'.* Renewable and Sustainable Energy Reviews, 2017. **73**: p. 452-459.

25. Al-Ghandoor, A., et al., *Projection of future transport energy demand of Jordan using adaptive neuro-fuzzy technique.* Energy, 2012. **38**(1): p. 128-135.

26. Hrayshat, E.S., *Analysis of renewable energy situation in Jordan.* Renewable and Sustainable Energy Reviews, 2007. **11**(8): p. 1873-1887.

27. Alkhalidi, A., et al., *Energy and water as indicators for sustainable city site selection and design in Jordan using smart grid.* Sustainable Cities and Society, 2018. **37**: p. 125-132.

28. Alrwashdeh, S.S., et al., *Improved Performance of Polymer Electrolyte Membrane Fuel Cells with Modified Microporous Layer Structures.* Energy

Technology, 2017. **5**(9): p. 1612-1618.

29. Alrwashdeh, S.S., et al., *Neutron radiographic in operando investigation of water transport in polymer electrolyte membrane fuel cells with channel barriers.* Energy Conversion and Management, 2017. **148**: p. 604-610.
30. Alrwashdeh, S.S., et al., *In Operando Quantification of Three-Dimensional Water Distribution in Nanoporous Carbon-Based Layers in Polymer Electrolyte Membrane Fuel Cells.* ACS Nano, 2017. **11**(6): p. 5944-5949.
31. Alrwashdeh, S.S., et al., *Investigation of water transport dynamics in polymer electrolyte membrane fuel cells based on high porous micro porous layers.* Energy, 2016. **102**: p. 161-165.
32. Sun, F., et al., *Complementary X-ray and neutron radiography study of the initial lithiation process in lithium-ion batteries containing silicon electrodes.* Applied Surface Science, 2017. **399**: p. 359-366.
33. Alrwashdeh, S.S., *Assessment of Photovoltaic Energy Production at Different Locations in Jordan.* INTERNATIONAL JOURNAL of RENEWABLE ENERGY RESEARCH 2018. **8**(2).
34. Mohammad A. Saraireh, F.M.A., and Saad S. Alrwashdeh, *Investigation of Heat Transfer for Staggered and in-Line Tubes.* International Journal of Mechanical Engineering and Technology 2017. **8**(11): p. 476–483.
35. Saad S. Alrwashdeh, F.M.A., Mohammad A. Saraireh, Henning Markötter,Nikolay Kardjilov, Merle Klages, Joachim Scholta and Ingo Manke, *In-situ investigation of water distribution in polymer electrolyte membrane fuel cells using high-resolution neutron tomography with 6.5 µm pixel size.* AIMS Energy, 2018. **6**(4): p. 607–614.
36. Hammad, M., M.S.Y. Ebaid, and L. Al-Hyari, *Green building design solution for a kindergarten in Amman.* Energy and Buildings, 2014. **76**: p. 524-537.
37. Al-Najideen, M.I. and S.S. Alrwashdeh, *Design of a solar photovoltaic system to cover the electricity demand for the faculty of Engineering- Mu'tah University in Jordan.* Resource-Efficient Technologies, 2017. **3**(4): p. 440-445.
38. Pillai, D.S. and N. Rajasekar, *A comprehensive review on protection challenges and fault diagnosis in PV systems.* Renewable and Sustainable Energy Reviews, 2018. **91**: p. 18-40.
39. Watson, S., et al., *Advantages of operation flexibility and load sizing for PV-powered system design.* Solar Energy, 2018. **162**: p. 132-139.
40. Bertrand, C., et al., *Solar irradiation from the energy production of residential PV systems.* Renewable Energy, 2018. **125**: p. 306-318.
41. Li, C., D. Zhou, and Y. Zheng, *Techno-economic comparative study of grid-connected PV power systems in five climate zones, China.* Energy, 2018.
42. Paital, S.R., et al., *Stability improvement in solar PV integrated power system*

using quasi-differential search optimized SVC controller. Optik, 2018. **170**: p. 420-430.

43. Yazdanifard, F. and M. Ameri, *Exergetic advancement of photovoltaic/thermal systems (PV/T): A review.* Renewable and Sustainable Energy Reviews, 2018. **97**: p. 529-553.

44. Zhu, J. and Z. Chen, *Optical design of compact linear fresnel reflector systems.* Solar Energy Materials and Solar Cells, 2018. **176**: p. 239-250.

45. Zhao, Y., et al., *Regenerative solar soil sterilizing system with the Fresnel lens concentrator.* Applied Thermal Engineering, 2018. **142**: p. 674-682.

46. Ajdad, H., et al., *Particle swarm optimization algorithm for optical-geometric optimization of linear fresnel solar concentrators.* Renewable Energy, 2019. **130**: p. 992-1001.

47. Song, J., et al., *A note on dispersion phenomenon in the fiber daylighting system with the Fresnel lens.* Solar Energy, 2018. **161**: p. 6-8.

48. Yang, Y., et al., *2 - Power electronic technologies for PV systems*, in *Advances in Grid-Connected Photovoltaic Power Conversion Systems*, Y. Yang, et al., Editors. 2019, Woodhead Publishing. p. 15-43.

49. Bressan, M., et al., *Development of a real-time hot-spot prevention using an emulator of partially shaded PV systems.* Renewable Energy, 2018. **127**: p. 334-343.

50. Kandemir, E., N.S. Cetin, and S. Borekci, *A comprehensive overview of maximum power extraction methods for PV systems.* Renewable and Sustainable Energy Reviews, 2017. **78**: p. 93-112.

51. Babu, C. and P. Ponnambalam, *The role of thermoelectric generators in the hybrid PV/T systems: A review.* Energy Conversion and Management, 2017. **151**: p. 368-385.

52. Mohapatra, A., et al., *A review on MPPT techniques of PV system under partial shading condition.* Renewable and Sustainable Energy Reviews, 2017. **80**: p. 854-867.

53. Yang, Y., et al., *5 - Advanced control of PV systems under anomaly grid conditions*, in *Advances in Grid-Connected Photovoltaic Power Conversion Systems*, Y. Yang, et al., Editors. 2019, Woodhead Publishing. p. 113-152.

54. Bahrami, A. and C.O. Okoye, *The performance and ranking pattern of PV systems incorporated with solar trackers in the northern hemisphere.* Renewable and Sustainable Energy Reviews, 2018. **97**: p. 138-151.

55. Krishna Kumar, N., V. Subramaniam, and E. Murugan, *Power Analysis of non-tracking PV system with low power RTC based sensor independent solar tracking (SIST) PV system.* Materials Today: Proceedings, 2018. **5**(1, Part 1): p. 1076-1081.

56. Afanasyeva, S., D. Bogdanov, and C. Breyer, *Relevance of PV with single-axis tracking for energy scenarios.* Solar Energy, 2018. **173**: p. 173-191.

57. Shabani, M. and J. Mahmoudimehr, *Techno-economic role of PV tracking technology in a hybrid PV-hydroelectric standalone power system.* Applied Energy, 2018. **212**: p. 84-108.

58. Samimi-Akhijahani, H. and A. Arabhosseini, *Accelerating drying process of tomato slices in a PV-assisted solar dryer using a sun tracking system.* Renewable Energy, 2018. **123**: p. 428-438.

59. Guichi, A., et al., *A new method for intermediate power point tracking for PV generator under partially shaded conditions in hybrid system.* Solar Energy, 2018. **170**: p. 974-987.

60. Beckman, J.A.D.a.W.A., *Solar Engineering of Thermal Processes*. Fourth Edition ed. Soalr Energy. 2013, Hoboken, New Jersey: John Wiley & Sons, Inc.

61. Kannan, N. and D. Vakeesan, *Solar energy for future world: - A review.* Renewable and Sustainable Energy Reviews, 2016. **62**: p. 1092-1105.

62. Khahro, S.F., et al., *Evaluation of solar energy resources by establishing empirical models for diffuse solar radiation on tilted surface and analysis for optimum tilt angle for a prospective location in southern region of Sindh, Pakistan.* International Journal of Electrical Power & Energy Systems, 2015. **64**: p. 1073-1080.

63. Le Roux, W.G., *Optimum tilt and azimuth angles for fixed solar collectors in South Africa using measured data.* Renewable Energy, 2016. **96, Part A**: p. 603-612.

64. Moghadam, H. and S.M. Deymeh, *Determination of optimum location and tilt angle of solar collector on the roof of buildings with regard to shadow of adjacent neighbors.* Sustainable Cities and Society, 2015. **14**: p. 215-222.

65. Skeiker, K., *Optimum tilt angle and orientation for solar collectors in Syria.* Energy Conversion and Management, 2009. **50**(9): p. 2439-2448.

66. Touati, F., et al., *Investigation of solar PV performance under Doha weather using a customized measurement and monitoring system.* Renewable Energy, 2016. **89**: p. 564-577.