Bitlis Eren Univ J Sci &
Technol
6 (1), 53-58, 2016

E - ISSN 2146-7706

Research Article

Solar Radiation and Temperature Effects on Agricultural Irrigation Systems

Olcay Palta[1], Çiğdem Cengiz[2], Metin Kaynaklı[1*]

[1] *Department of Technical Vocational School, Bitlis Eren University, Bitlis - Turkey*
[2] *Department of Faculty of Science and Arts, Bitlis Eren University, Bitlis - Turkey*
[*] *Corresponding author: kaynaklim@hotmail.com*

Abstract

Day by day water resources in the world are getting shortened and agricultural lands are gradually getting dry. Water extraction for agricultural purposes in the regions far away from the electric network, brings extra costs. In the regions that are close to the electric network, high electric bills are encountered. In irrigation systems, cost-efficient and high performance power generation is possible thanks to the solar energy. When parameters such as the quantity of water and the well height required are known, cost-efficient agricultural irrigation can be achieved by proper pump selection. In this study; dynamic change realized on daily and annual basis was researched for off-grid photovoltaic pump system (PVPS) that is attached to photovoltaic (PV) panels. In this system, PV panels are directly attached to the pump that feeds a tank placed high above. According to the measurements performed in the application area, Malatya province; analyzes were carried out on solar radiation, change of temperature, electrical efficiency and pump water flow. Months that had similar solar radiation and temperature values, were gathered under three different groups. That is, instead of monthly data, months that were of similar nature, were named as the Warm period, Lukewarm period and Cold period. In consequence of the study, major changes were observed in the system flow and efficiency throughout the day. Therefore, it was determined that designing any PVPS application according to daily average values without investigating the dynamic process, would cause performance decrease and additional costs.

Keywords: Solar Efficiency; Solar Radiation, Photovoltaic Panel System, Energy Efficiency.

1. Introduction

Today, solar energy is practically and economically used in agricultural irrigation systems. Thanks to the developments in PV panel and control devices; PVPS design, installation, operation and maintenance have become easier. Therefore, if there is a need for water at any point, the solution in terms of reliability and sustainability, is PVPS.

However, the main problem here is that; the number of panels used in PV systems are more than adequate, and accordingly, the costs are increased. With this study, it was aimed to prevent the installation of high cost systems, in other words, to provide the maximum water flow made possible by using less PV panels.

When choosing a pump system, purchase and assembly costs are usually analyzed. However; purchase and assembly cost, is a very low cost compared to the energy used during the operation of the system. In literature, there are studies indicating that the purchase price of a pump throughout its total lifetime, is 3.6%, assembly price is 6.6%, and the total energy consumed by the pump, is 92.8% [1-9].

Incidence angle of sunbeams to the earth, is depended on the hour angle of the world throughout the day, and on the declination angle throughout the year. This change on daily and yearly basis, also cause changes in several meteorological data such as radiation intensity and ambient temperature. Due to the change observed in the meteorological data on daily and yearly basis; electrical efficiency in the solar energy applications, changes throughout the day and the year. This change observed in PV panel systems, particularly established for agricultural irrigation, increases the importance of optimization and design. Because, sudden changes in the meteorological data, do affect the current-voltage I-V) characteristics and radiation intensity of PV panels, and the ambient temperature, therefore these changes also affect the system output, that is, the pump water flow [9-21].

2. PV Pump system

The most suitable solution for agricultural-purpose or any other pump; is depended on the parameters such as altitude changes at the point of application, on whether there is an inverter available in the system, and on which season of the year and which hour of the day the water should be used. PV irrigation systems that have the highest efficiency, are the systems in which batteries are not used, and PV panels are directly activated via a control device. Off-grid PV panel group was directly attached to a DC submersible pump. The water was transferred to a tank that had been placed higher than the point where the water would be used [21-62]. The system diagram related to the PVPS analyzed, was shown in Figure 1.

Received 20 June 2016
Available online June 2016

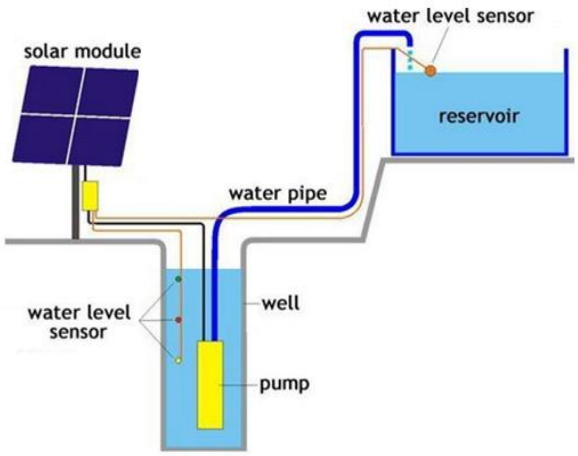

Figure 1. Directly bowered PVPS chart

Two important parameters affecting the electrical efficiency of PV panels, are solar radiation and temperature. The location of any place is expressed with the latitude and longitude on which it is situated. Solar radiation values of this place are fixed, and impossible to change. Other parameter that affects the electrical efficiency of PV panels, is temperature and it is open to intervention. That is, PV panels can be heated and cooled down by external intervention. Therefore, it is required to reduce PV panel temperature in order to increase the electrical efficiency of PV panel, or to increase the number of PV panels in order to meet the demanded power.

Meteorological data related to the period between May-2013 and April-2014, were monitored and recorded instantaneously. Arithmetic mean was calculated for each month, and daily global radiation values were calculated. In Figure 2, daily average global radiation values in a month in Malatya, are indicated

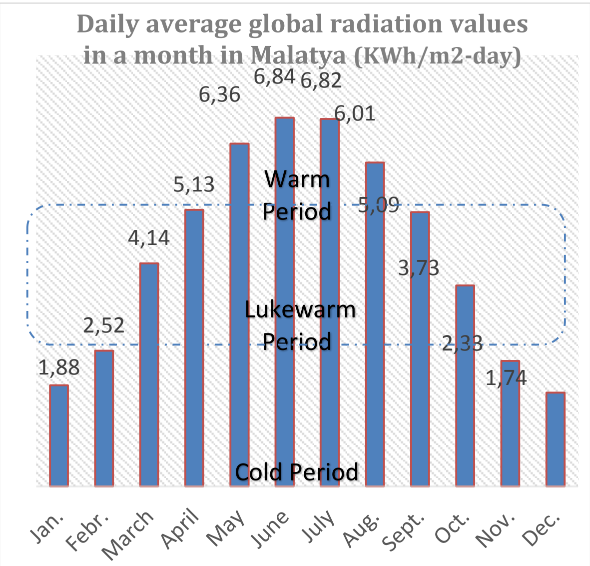

Figure 2. Daily average global radiation values in a month in Malatya

In order to determine the temperature related to the months, arithmetic mean of the total temperature was calculated for each month, depending on daily temperature values. In Figure 3, daily average temperature values in a month in Malatya, are indicated.

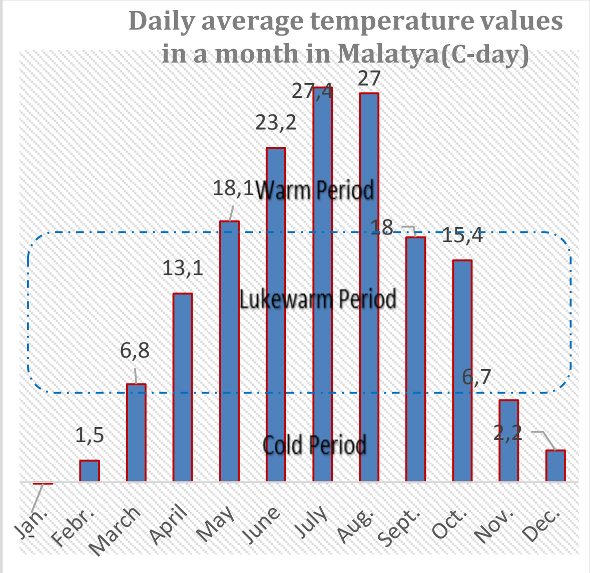

Figure 3. Daily average temperature values in a month in Malatya

Instead of making a separate calculation for each month, basing upon 12 months of a year; months that were of the similar nature, were evaluated in three different groups in terms of solar radiation and ambient temperature. In this approach, as a result of classifying the months together, which produced similar results in accordance with radiation intensity and ambient temperature parameters, we can see that three different groups have appeared. These groups were called as the Warm period (May-June-July,-August), Lukewarm period (March-April-September-October) and Cold period (January-February-November-December) in accordance with their radiation intensity and temperatures. The advantage of this classification is that; it is possible to reach correct results by looking at the solar radiation and temperature at any place located on a latitude-longitude point different from where we are. Because, by this means, it might be considered that Cold period, Lukewarm period and Warm period represent the places that have low, medium and high radiation intensity and temperature values, respectively. Thus, correct results on the system efficiency can be achieved by looking at the temperature and radiation values without making any calculation.

For the application area, an evaluation was carried out in four-month groups. By means of calculating the arithmetic means of these groups; hourly solar radiation and temperature values were compared in terms of electrical efficiency and pump water flow for one day, and a detailed analysis was carried out.

3. Conclusion the impact of radiation intensity and ambient temperature on the water flow

The daily change of solar radiation belonging to each group, was shown in Figure 4; and the daily change of ambient temperature, was shown in Figure 5. Here, the point that needs to be paid attention is that, the group that has the highest radiation intensity, also has the highest temperature value at the same time. In terms of PV systems, high radiation intensity is positive for the system performance. However, high temperature creates a negative impact on PV system, and reduces the efficiency. In addition, high temperature causes the vegetables and the other creatures consume more water. Therefore, in order to meet the water requirement instantaneously, more PV anels are used for more water flow in the regions located on warm climate zone. And this cause an increase in start-up costs. That is, it is not right to make a decision on the performance by only looking at the radiation intensity.

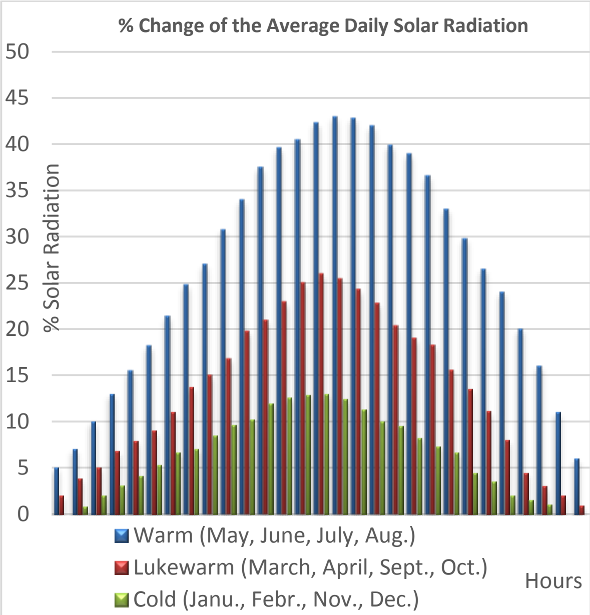

Figure 4. The change of daily radiation intensity in terms of efficiency

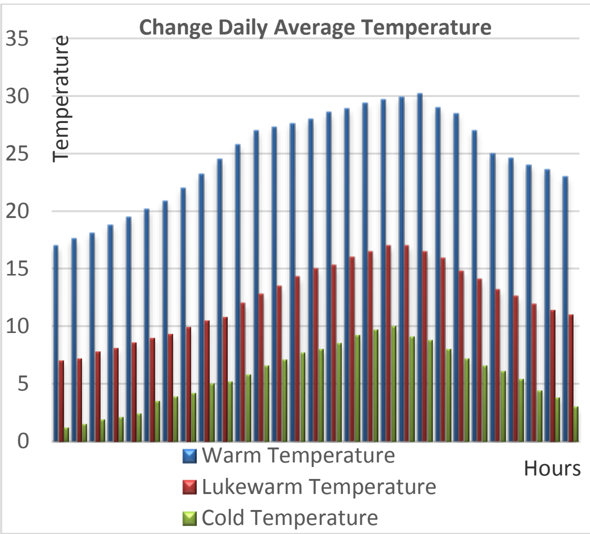

Figure 5. The change of average daily ambient temperature

As it can be seen in Figures 4 and 5, there is a dynamic change in the radiation intensity and ambient temperature throughout the day. It can also be seen that the ambient temperature fluctuating in the same direction with the radiation intensity, adversely affects the efficiency of direct-connected systems [11-13].

It is an understandable issue that the efficiency is reduced as the temperature rises; and the issue that the efficiency is reduced as the radiation intensity rises, can be explained by going down to the optimum temperature values.

4. The Impact of meteorological conditions on the water flow

In three different periods determined for Malatya that had been chosen as the application area, daily change of current dynamic process under instantaneous radiation intensity and ambient temperature. The impact that these dynamic values created on the system output, was measured by the pump flow for system efficiency, and the results acquired are indicated in Figures 6, 7 and 8. There were serious noticeable changes in the system outputs throughout the day. The highest amount of water drawn, was acquired for the Warm period in every hour of the day. However, Cold period, that is expected to include the lowest amount of water drawn by PVPS, pumps more water in the early and late hours of the day when compared to the Lukewarm period. This is because, the ambient temperature is quite low for the Cold period, and the radiation intensity in this period, are very close to the optimum values. This impact was verified by looking at the change in the amount of water pumped into the tank. This outcome is opposed to the general expectations. When Figure 6 is analyzed, efficiency in the Warm Period is at its peak in every hour of the day. For PVPS, it can be clearly seen that the efficiency is reduced as the radiation intensity rises. This decrease in the efficiency, needs the use of more panels in order to reach the flow required in large pump systems.

In order to prevent the use of more PV panel, in other words, in order to reduce the start-up cost, it was intended to reduce the temperature on PV panel. To this end, a fan with cooling function was assembled into the system, and electrical yield at different levels was gained for the Warm, Lukewarm and Cold periods by reducing PV panel temperature. Thus, there was an increase in the amount of water transferred into the tank. The daily change of electrical efficiency, solar radiation, temperature and water flow for the Warm Period, was shown in Figure 6, for the Lukewarm period in Figure 7, and for the Cold period in Figure 8.

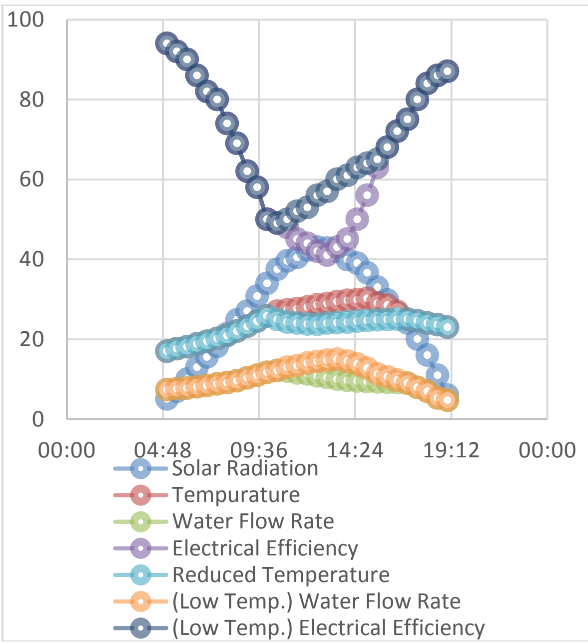

Figure 6. The daily change of electrical efficiency, solar radiation and water flow in the Warm period

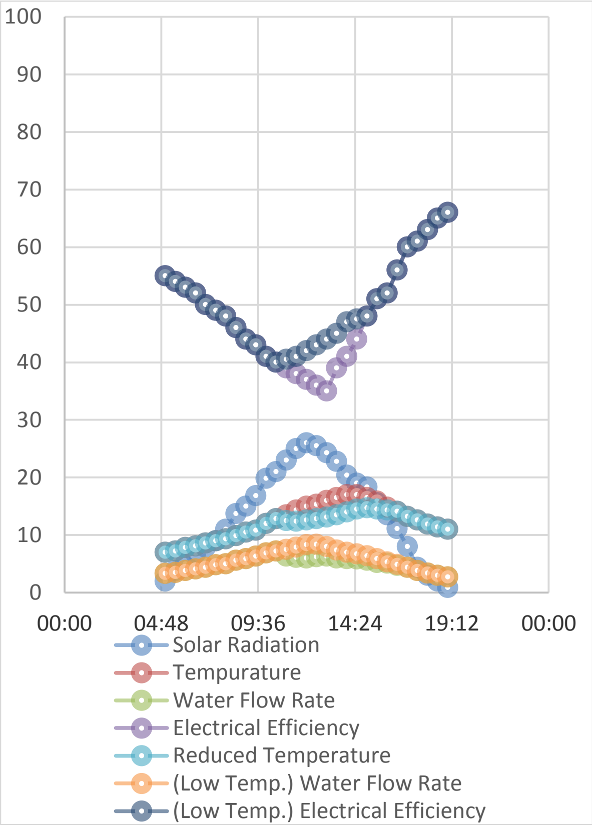

Figure 7. The daily change of electrical efficiency, solar radiation and water flow in the Lukewarm period

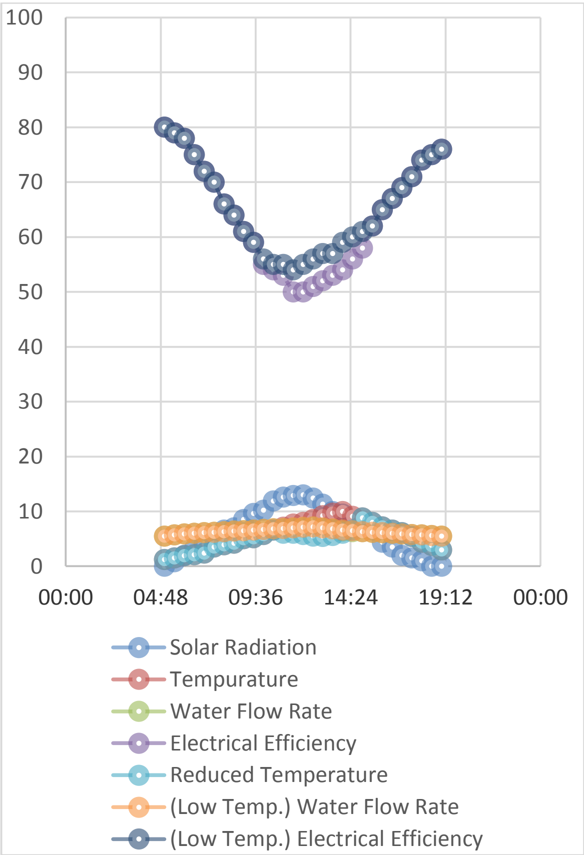

Figure 8. The daily change of electrical efficiency, solar radiation and water flow in the cold period

When Figures 6, 7 and 8 are analyzed together, it is understood that the solar radiation is stable, meaning it cannot be changed. And, temperature parameter is open to external intervention. In other words, the temperature of PV panel can be increased or reduced when desired. In Figures 6, 7 and 8, it can be seen that at the moments when the temperature was maximum for each three groups, the electrical efficiency was minimum, therefore the water transferred into the tank, was also minimum. When a fan was assembled into the system to reduce the temperatures of PV panels, the system temperature was decreased. The decreased state of system temperature, was indicated by red dashed lines. Therefore, the quantity of water transferred into the tank, showed an increase at the rates of approximately 17%, %11 and 5% for each three groups.

Warm period, was the group that was mostly affected by the temperature in terms of electrical efficiency. It was also the group that had the greatest increase in the electrical efficiency and in the water flow when the temperature was decreased. In the Lukewarm period, a recovery at the rate of 11%, was observed. And in the Cold period, PV panels ran closely to the maximum performance because the ambient temperature was not high. Therefore, the cooling operation in the Cold period, provided a recovery of 5% at the most.

According to this application, the use of fan in order to reduce the temperature in the Warm and Lukewarm periods, was at a convincing level in terms of efficacy rates. Another way to acquire the energy generated by PVPS, is to add PV panels to the system. However, in the application conducted, it was observed that it was required to use a 400W panel instead of a 300W panel. And this, increased the system cost at 33%. As Current-Tension characteristics of PV panels are non-linear and because they would run by one motor, these types of systems do not reach the maximum performance. Because in order to run closely to the maximum performance, panel connection configuration is needed to be optimized in the large systems that use more than one panels.

As the system already runs closely to the maximum performance in the Cold period and because the additional yield it provides is 5%, an extra fan for cooling down the system is unnecessary. Fan increases the extra cost burden.

5. Conclusions

For a selected PVPS system, the dynamic change in the performance depending on the instantaneous change in the daily radiation intensity and ambient temperature during three different periods determined for Malatya, was analyzed. Due to the relationship between the radiation intensity and ambient temperature, these periods might be considered as; cities and regions that have low instantaneous average radiation intensity are included in the Cold Period; cities and regions that have medium instantaneous average radiation intensity are included in the Lukewarm Period; and cities and regions that have high instantaneous average radiation intensity are included in the Warm Period.

- The selected PVPS application can reach a high performance in the regions that particularly have low ambient temperature average. The reasons for high performance are; the proximity between the maximum operating point of the panel and system, and the positive impact of low ambient temperature on PV system efficiency. In other words, as the sunbeams do not reach high temperatures during sunrise and sunset, they positively affect the efficiency. As it can be seen in Figures 6, 7 and 8, there have been great changes observed particularly in the flow and the system performance. Accordingly, when making a PV system selection for any region, the reaction that the system would make against the changes in the meteorological conditions of the region throughout the day and the year, should also be taken into consideration. Otherwise, the system performance would be far less than expected, or the purchase of more PV panels would be required. Purchasing more PV panels also increases the system cost. In addition, as the pumps have non-linear characteristics, PV panels included in the system, should be revised. Because for efficiency at the maximum performance, panel connection configuration should be optimized in the large systems that use more than one panels.

- When high temperature values were reached, a cooling fan was assembled into the system in order to prevent the electrical efficiency and water flow from decreasing. As the temperature was decreased, a rise in the electrical efficiency and in the water flow was observed. In Figures 6, 7 and 8, the increase in electrical efficiency and water flow is indicated by dashed lines.
- The greatest advantage of this system is, its simplicity.
- In this system, the water tank operates as an accumulator, and it has stored the pumped water in order to consume it later. Water that would suffice for a few days in the tank, was stored in optimum-scaled direct storage PVPS, and it was observed that there was enough water even when the PVPS was not running. Thanks to this method, no accumulator or generator were needed.
- As the tank was placed much higher than the consumption points, it provided the adequate pressure. Extra pressure pumps and pressure tanks were not required.
- In sunny days, PVPS filled the storage tank slowly and the system did not run when there was no sun. Because the weather continuously kept opening and closing in cloudy.

References

[1] Gençoğlu MT, Cebeci, M., 2000. Türkiye'nin Enerji Kaynakları Arasında Günes Enerjisinin Yeri ve Önemi, Türkiye 8. Enerji Kongresi, 63-73 , Ankara.

[2] Renewables Global Report Status, 2015, http://germanwatch.org/klima/gsr2011.pdf.

[3] European Photovoltaic Industry Association, "Global Market Outlook for Photovoltaic Until 2015," 2015, http://www.epia.org/.

[4] Solar Photovoltaics, 2015, https://www.irena.org/DocumentDownloads/Publications/RE_Technologies_Cost_Analysis-SOLAR_PV.pdf.

[5] Cengiz MS. Mamiş MS. 2015. Price-Efficiency Relationship for Photovoltaic Systems on a Global Basis, International Journal of Photoenergy, 2015(2015), Article ID 256101, 12 pages.

[6] Renewable Energy Technology Cost Review, May 2015, http://www.energy.unimelb.edu.au/files/site1/docs/39/Renewable%20Energy%20Tech%20Cost%20Review.pdf.

[7] Global Photovoltaic Business, May 2015, http://www.interpv.net/market/market_view.asp?idx=94&part_code=03.

[8] The International Energy Agency, Technology Roadmap: Solar Photovoltaic Energy, The International Energy Agency, 2015, https://www.iea.org/publications/freepublications/publication/pv_roadmap.pdf.

[9] Gençoğlu MT, 2002. Yenilenebilir Enerji Kaynaklarının Türkiye Açısından Önemi, Fırat Üniversitesi Fen ve Mühendislik Bilimleri Dergisi,, 14(2), 57-64.

[10] Technology Roadmap Solar Photovoltaic Energy, May 2015, http://www.iea.org/publications/freepublications/publication/pv_roadmap.pdf.

[11] Renewable Energy Technology Cost Review, May 2015, http://www.garnautreview.org.au/update-2011/commissioned-work/renewable-energy-technology-cost-review.pdf.

[12] L. El Chaar, L. A. Lamont, and N. El Zein, "Review of photovoltaic technologies," Renewable and Sustainable Energy Reviews, vol. 15, no. 5, pp. 2165–2175, 2011.

[13] Cengiz MS. Mamiş MS. The Determination of the Optimum Parameters for Maximum Efficiency in Solar Tracking systems with Stirling Engine, International Conference on Natural Science and Engineering, pp. 2109-2118, March 19-20, 2016, Kilis, Turkey

[14] Survey of Photovoltaic Industry and Policy in Germany and China, July 2015, http://climatepolicyinitiative.org/wp-content/uploads/2011/12/PV-Industry-Germany-and-China.pdf.

[15] Technology Roadmap Solar photovoltaic energy, http://www.poweracrosstexas.org/wp-content/uploads/2011/01/solar-technologyroadmap .pdf.

[16] Achieving Low-Cost Solar PV, June 2015, http://www.rmi.org/Content/Files/BOSReport.pdf.

[17] Gençoğlu MT, 2005. Günes Enerjisi Ile Çalısan Su Pompalama Sistemleri, 3e ELECTROTECH, 134, 94-97.

[18] PV Status Report, March 2014, http://www.cetcsolarenergy.com/downloads/PV_Status_Report_2009.pdf.

[19] C. Ballif, Innovative Forschungsprojekte im Bereich Solar und Photovoltaik EPFL, vol. 5 of Energie-Cluster, Institute of Microengeering, IMT, Photovoltaics and Thin Film Electronics Laboratory, Neuchâtel, Switzerland, 2011.

[20] Webcast: centrotherm's "grid parity factory", June 2015, http://www.centrotherm.de/fileadmin/ct_group/Downloads/IR_Sonstige/Konferenzen/090204_WebCast_IntegrierteFabrik_EN.pdf.

[21] Gençoğlu MT, Cebeci M, 2000. Türkiye'nin Enerji Kaynakları Arasında Günes Enerjisinin Yeri ve Önemi , Kaynak Elektrik, 138, 110-115.

[22] The Garnaut Review 2011, 2011, http://www.garnautreview.org.au/update-2011/commissioned-work/renewable-energy-technology-cost.pdf.

[23] M. Kezunovic and S. T. Waller, "PHEVs and BEVs in coupled power and transportation systems," in Encyclopedia of Sustainability Science and Technology, pp. 7847–7865, Springer, New York, NY, USA, 2012.

[24] N. Mori, "Current status and future prospect of photovoltaic technologies in Japan," in Proceedings of the Conference Record of the 28th IEEE Photovoltaic Specialists Conference, PVTEC (Photovoltaic Power Generation Technology Research Association),

Septemper2000, http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=916238.
[25] The Photovoltaic Industry, June 2015, http://www.evwind.es/2010/09/14/the-photovoltaic-industry.
[26] Efe SB. 2015. Harmonic Filter Application for an Industrial Installation, IEEE The 13th International Conference on Engineering of Modern Electric Systems, 11-12 June, Oradea, Romania.
[27] Ertugrul ÖF. 2016. Forecasting electricity load by a novel recurrent extreme learning machines approach. International Journal of Electrical Power & Energy Systems, 78, pp 429–435.
[28] Efe SB. Cebeci M. 2015. Artificial Neural Network Based Power Flow Analysis for Micro Grids, Bitlis Eren Univ J Sci & Technology, 5(1), pp. 42-47.
[29] Efe SB., 2016. Effects of Faults on Power-Flow Analysis for Microgrids, 8th International Ege Energy Symposium and Exhibition, Afyon, 11-13 May.
[30] Solar Generation 6, 2015, http://buildgreenworld.co/PDF/2/EPIA%20Solar%20PV%20Electricity%20Empowering%20World%202011.pdf.
[31] S. Mehta, PV Technology, Production and Cost Outlook: 2010–2015, GTM Research, 2011.
[32] Cengiz MS. 2014. Evaluation of Smart Grids and Turkey, Global Advanced Research Journal Of Engineering Technology and Innovation, 3(7), pp. 149-153.
[33] Yurci Y. Cengiz MS. Smart Grid on Optimization, International Conference on Natural Science and Engineering, pp. 2143-2147, March 19-20, 2016, Kilis, Turkey
[34] Cengiz MS. 2014. System Optimization On Smart Grid, International Journal of Electrical and Electronics Engineering, 1(8), pp. 28-32.
[35] $1/W Photovoltaic Systems White Paper to Explore A Grand Challenge for Electricity from Solar, June 2015, http://www1.eere.energy.gov/solar/pdfs/dpw_white_paper.pdf.
[36] Solar energy engineering: processes and systems, 2015, http://library.uniteddiversity.coop/Energy/Solar/Solar_Energy_Engineering-Processes_and_Systems.pdf.
[37] Ertugrul ÖF. Korkmaz G. 2012. Güneş Hibrit Jeotermal Enerji ve Batman – Taşlıdere'de Güneş Hibrit Jeotermal Enerji ile Elektrik Üretim Örneği, Ulusal Enerji Verimliliği Forumu (UEVF2012), Ocak 2012, Syf:103-109.
[38] Solar Energy Engineering-Processes and Systems, June 2015, http://library.uniteddiversity.coop/Energy/Solar/Solar_Energy_Engineering-Processes_and_Systems.pdf.
[39] İlcihan Z. 2016. Energy Saving and Optimum Solution in Electric Motors, International Conference on Natural Science and Engineering, March 19-20, Kilis, Turkey
[40] Atiç S. 2016. Energy Efficiency Studies and Practical Solutions in Industrial Plants, International Conference on Natural Science and Engineering, March 19-20, Kilis, Turkey
[41] Parlakyıldız Ş. 2016. Frequency-Load Problem In Power Systems, International Conference on Natural Science and Engineering, March 19-20, Kilis, Turkey
[42] Parlakyıldız Ş. Gençoğlu MT. 2016. Reazilation of the Dynamic Test and Measurement System for Railway Electrification Systems, International Conference on Natural Science and Engineering, March 19-20, Kilis, Turkey
[43] JRC Scientific and Technical Report: PV Status Report, June2015,http://www.rpia.ro/wp-content/uploads/2012 /03/LBXB11001ENC_0021.pdf.
[44] Photovoltaic System Pricing Trends, 2014, http://www.nrel.gov/docs/fy14osti/62558.pdf.
[45] Cengiz M.S., Mamiş M.S., (2015). Heat Source Solar Energy Use in Turkey and in the World and Efficiency Evaluation of CSP Stirling Engine System. International Symposium On Eurasia Energy Issues, pp. 225-236, 28-30 May 2015, İzmir.
[46] Cengiz M.S., Mamiş M.S., (2015). Endüstriyel Tesislerde Verimlilik ve Güneş Enerjisi Kullanımı VI. Enerji Verimliliği Kalitesi Sempozyumu ve Sergisi, pp. 21-25, Sakarya, Türkiye
[47] Solar Photovoltaics: Technology Brief, 2015, https://www.irena.org/DocumentDownloads/Publications/IRENA-ETSAP%20Tech%20Brief%20E11%20Solar%20PV.pdf.
[48] Module Prices, July 2015, http://solarbuzz.com/facts-and-figures/retail-price-environment/module-prices.
[49] Renewable Energy Technology Cost Review, June 2015, http://mei.insights4.net.au/files/site1/docs/39/Renewable%20Energy%20Tech%20Cost%20Review.pdf.
[50] Ertugrul ÖF. 2016. Forecasting electricity load by a novel recurrent extreme learning machines approach. International Journal of Electrical Power & Energy Systems, 78, pp 429–435.
[51] PES Essential: EPİA Report, January 2015, http://www.pes.eu.com/assets/misc_new/epa-market-outlook-2015pdf-680788895531.pdf.
[52] Photovoltaics—potential, markets and technological progress: Solar Energy Research Institute of Singapore, July 2015, http://www.seris.sg/main/Download/4322/pdf_13052011_semcon_%202011html
[53]Cengiz M.S., Mamiş M.S., A Research On Determining The Panel Inclination Angle In Terms Of The Place And Seasons, Journal of Multidisciplinary Engineering Science and Technology, 2015, 2(8), pp. 2172-2177.
[54] The State of the PV Industry—An Association Perspective, July 2015, http://avsusergroups.org/joint_pdfs/2011-2savala.pdf.
[55] Cengiz M.S., Mamiş M.S., Thermal Solar Energy Use and Turkey Analysis, Bitlis Eren Univ. J. Sci & Technol. 2015, 5(2), pp. 88-91.
[56] H. Müller-Steinhagen, M. R. Malayeri, and A. P. Watkinson, "Heat exchanger fouling: environmental impacts," Heat Transfer Engineering, vol. 30, no. 10-11, pp. 773–776, 2009.
[57] Kocaman B., Abut N., 2015. " The Role of Energy Management in Microgrids With Hybrid Power Generation System", Bitlis Eren University Journal of Science and Technology, 5 (1), 31 - 36.
[58] Cengiz M.S., Rustemli S. The Relationship Between Height and Efficiency and Solution Offerings in Tunnel and Sub-Sea Tunnels, Light Engineering, 2014, 22(2), pp. 76-83.
[59] Rustemli S., Cengiz M.S. Active filter solutions in energy systems, Turkish Journal of Electical Engineering & Computer Sciences, 2015, 23(6), pp. 1587-1607.
[60] Cengiz M.S., Smart Meter and Cost Experiment, Przeglad Elektrotechniczny, R. 89 NR 11/2013, pp: 206-209.
[61] Rustemli S., Cengiz M.S. 2016. The Reduction of Passive Harmonic Filters, International Conference on Natural Science and Engineering, March 19-20, Kilis, Turkey
[62] Kocaman B .,2014. Mikro Şebekeler İçin Örnek Bir Enerji Yönetimi Uygulaması, Bitlis Eren Üniversitesi Fen Bilimleri Dergisi, 3(1), pp.35-52.