0164 - FIELD PERFORMANCE ANALYSIS OF A NOVEL MOBILE SOLAR IRRIGATION SYSTEM WITH TWO-AXIS SUN-TRACKER

***Ümran Atay[1,2], Yusuf Işiker[2], Bülent Yeşilata[2]**
[1]*GAP Agricultural Research Institute-Sanliurfa/Turkey*
[2]*Harran University GAP YENEV R&D Center- Sanliurfa/Turkey*

ABSTRACT

This study provides technical details for main components of an innovative mobile solar irrigation system, which we designed and manufactured. The irrigation system has 32 photovoltaic (PV) panels (at 170 W nominal power), 6 changeable pump heads (0-70 ton/h flow rates at 0-170 m well-depth) and 1 direct-current (DC) motor with its driver. The irrigation system as a whole is placed on a trailer to allow its easy mobilization to the desired field. The system has an automatic two-axes sun tracking unit for PV panels. Field experiments performed with this mobile solar irrigation system motivate that this type of application has both technical and economical advantages.

Key words: Photovoltaic panel, solar battery, DC pumps, mobile solar Irrigation system

1. INTRODUCTION

Since the cost of the power supplied by the ordinary energy resources is high, the utilization of new and renewable energy resources for irrigation has come into prominence. The utilization of natural energy resources, instead of fossil fuels, has become privileged to protect the existing reserves and the environment. Among the prime advantages of the solar irrigation units, compared to the irrigation systems powered by internal combustion engines, are the near-zero maintenance requirements, long-lasting utilization periods, non-requirement of any fuel, and no impact on environmental pollution (Atay at al., 2012a). During the irrigation season, the period of time in which the irrigation needs rise to the maximum level is when the maximum solar irradiation is reaches to earth. This fact could be considered as a superiority of such systems (Köksal, 2012)., However, high investment costs and the dependence of solar irrigation systems are among the main disadvantages (Yeşilata ve Fıratoğlu, 2008). No significant problem has been encountered, during the field tests with power accumulation or without battery packages under Sanliurfa's climatic conditions.

Between May and September, during which the maximum amount of solar irrigation is received, solar powered irrigation is realized without any negative consequence (Atay at al.., 2012b). It is emphasized by Kaldellis at al. (2009), Mokeddem at al. (2011), and Qoaider and Steinbrecht (2010), as well, that the solar powered irrigation systems are a significant alternative to the systems lived on the national grids.

The studies performed to investigate the methods to decrease the power consumption of the irrigation applications in recent years point out the necessity to develop low-cost and high-effective solar irrigation systems, as an alternative to the systems based on fossil fuels. This study includes general information on a "**Mobile Solar Irrigation Device**", a unique device designed and manufactured to be an alternative to the existing conventional irrigation units and to step up the solar photovoltaic applications in irrigation.

2. METHOD

This study reveals the results of the performance tests on a mobile solar irrigation unit, operated in the GAP Agricultural Research Institution's Koruklu Research Station field. The said station is located on north 36^o 42 latitude and 38^o 58' east longitude, and its elevation from the sea level is 410 meters (Anonymous, 2002). The mobile irrigation system, through its mechanism, both tracks the solar irradiation in two axes (east-west and north-south) and could be transported to any field, owing to its mobility. When an obstacle is observed in the horizon, it could be removed with ease. The system has 32 pieces of solar photovoltaic panels, with 170 W maximum power generation capacities. Since the photovoltaic panels receive the sunlight perpendicular or near-perpendicular to the surface, they are exposed to maximum sunlight during the daytime (Atay at al., 2013).

The significant elements of the mobile solar irrigation system are presented below:

- 32 pieces of solar photovoltaic panels at 170 maximum power production,
- One DC pump ((3.5kW/4.6 HP, MPPT control unit)
- 6 pieces of pump headings (within the range of 0 to 170 m of depth and 0 to 70 tons/hour of volume rate)

The energy need of the solar tracking system is fulfilled by the power generated by the photovoltaic panels. The system has 2 pieces of batteries and 24 VDC (230 Ah), one MMPT device, one AC/DC inverter, one DC pump and one AC pump (1.1 kW @ 220 VAC), an electrical panel and other related elements.

The picture of the mobile solar irrigation system is presented in Figure 1. In general, the variables, including the radiation density, current, voltage temperature, and instant and total flow rate is recorded. During the irrigation, the direction arrow is located in north. Thus, the photovoltaic panels are assured to receive the maximum amount of solar irradiation during the irrigation season. The system is designed to track the sunlight and with a panel folding system during the travel.

Figure 1. Mobile solar powered irrigation system.

3. FINDINGS

The solar powered mobile irrigation system is transferrable to any field without any challenge, as could be seen in Figure 2. The PV platform is designed to be folded to the center.

Figure 2. The transportation of the mobile solar irrigation system

The performance parameters of the system have been recorded during its operation in the field. The pump has been operated, within a depth range of 0-13 meters) for 10.33 hours on February 25th 2014. With the irradiation rate of 64 W/m^2 recorded at 06:29 am, the DC pump was operated by consuming 2138 W DC power at the beginning. The panel temperature was recorded as 5^{o}C in the morning and it rose to 5 ^{o}C in mid day. The temperature in shadow was 5^{o}C in the morning and this figure and went up to 30 ^{o}C during the mid day and descended to 24 ^{o}C' at 16:49 pm. The rate of solar radiation density was changed between 0 W/m^2 and 1019W/m^2. The solar radiation received by the photovoltaic panels in total was 270.85 kW. The amount of the pumped water during the day was 552 tons. The total efficiency of the power consumed by the pumping system was recorded as 9.39%. The maximum efficiency was 15% while the lowest figure was 7.64%.

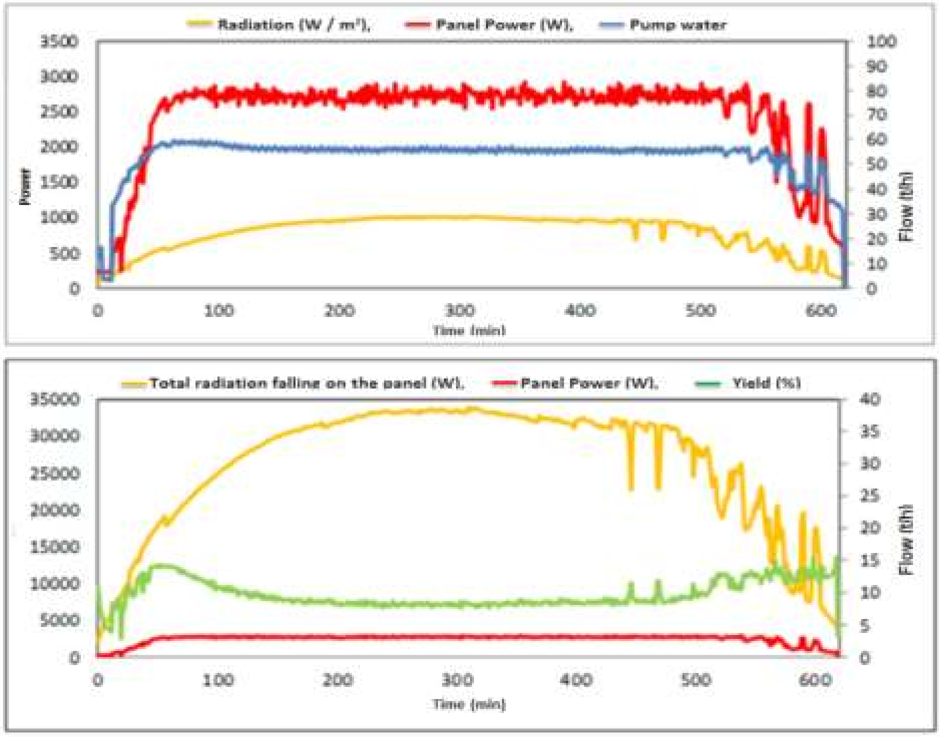

Figure 3. Full day performance graphs of the system on March 03rd, 2014

4. RESULTS

The mobile solar irrigation system commences the operation together with the sunrise and ceases its operation at sunset. As the machine follows the sunlight through its tracking system, the irrigation tests have been thrived, partly depended on a limited number of overcast days. No problem has been observed in the next day operation of the system in long hours. The tested system has advantages over an alternative batter-supported solar irrigation unit, as long as it is designed with an enough number of power supplying panels. The battery packages, in general, fail at the end of the second year. Thus, the design of the solar-powered irrigation systems requires the incorporation of photovoltaic solar photovoltaic panels at enough power generation capacity.

This study powerfully indicates that there is no significant challenge in the utilization of solar power in agricultural irrigation. It is beneficial through the employment of a single mobile unit in several fields during the same season, specifically in those without national power grid.

Acknowledgement

This paper is prepared within the scope of the "Configuration of a Mobile Solar Photovoltaic Irrigation System and the Investigation of Effectiveness in Comparison to the Other Irrigation Systems Powered by Conventional Energy Resources", a project supported by the TUBITAK-TOVAK group with the number 110O541. The authors also acknowledge the great support provided by Dr. Muhyettin Sirer at UNDP-Turkey Office.

REFERENCES

Anonim, (2002). Hidrometeorolojik rasat verileri. Köy Hizmetleri Şanlıurfa Araştırma Enstitüsü

Atay Ü., Yeşilata B., İşıker Y., Çıkman A., Nacar A.S., Rastgeldi U., Polat R., Başçetinçelik A ve Çetiner İ. H., 2012a. Güneş Pili Destekli Damla Sulama Sistemlerinin Kurulumu Ve Sistem Performansının Teknik Ve Enerji Maliyeti Yönünden Karşılaştırılması (Şanlıurfa Örneği), Sonuç Raporu. GAP Tarımsal Araştırma Enstitüsü Müdürlüğü proje No: TAGEM-topraksu-2012/138, Şanlıurfa.

Atay Ü., Y. Işıker, B. Yeşilata, U. Rastgeldi, (2012b) "Seyyar (Mobil) Güneş Pili Sulama Sistemli Prototip Makinanın Tasarımı ve İmalatı" Tarım Makinaları Bilimi Dergisi, ISSN 1306-0007, 2012 8 (2) SAF.147-151 (27. Tarımsal Mekanizasyon ulusal kongresi. Samsun.

Atay, Ü., İşıker, Y., Yeşilata, B., ve Başçetinçelik, A., 2013. Mobil Güneş Pili Sulama Makinasının Arazi Koşullarında Bazı Deneysel Çalışmaları. Tarım Makinaları Bilimi Dergisi (Tarmek-2013-Konya). ISSN 1306-0007. Cilt 9, sayı 2, sayfa 135-139.

Kaldellıs, j.k., spyropoulos, g.c., kavadıas, k.a., koronakı, I.P. (2009). Experimental validation of autonomous PV-based water pumping system optimum sizing. Renewable Energy 34(4): 1106–1113.

Köksal M. A., 2012. Güneş Enerjisiyle Su Pompalama Üzerine Bir Araştırma, yüksek lisans tezi, Tarım Makinaları Anabilim Dalı Ç.Ü. Adana.

Mokeddem, A., Mıdoun, A., Saıd Hıadsı, D.K., Raja, I.A. (2011). Performance of a directly-coupled PV water pumping system. Energy Conversion and Management 52(10): 3089–3095.

Qoaıder, L., Steınbrecht, D. (2010). Photovoltaic systems: A cost competitive option to supply energy to off-grid agricultural communities inarid regions. Applied Energy 87(2): 427–435.

Yeşilata, B., Fıratoglu, Z.A. (2008). Effect of solar radiation correlations on system sizing: PV pumping case. Renewable Energy 33: 155–161.