Available on: http://gjetr.ep-journals.org/ E-ISSN: 3051-3782, P-ISSN: 3051-3774

Global Journal of Engineering and Technology Review
Volume: 02 Issue: 06 June 2026

Analysis of the Effect of the Solar Water Pumps Systems (SWPS) on Increasing the Economy of Farmers in Kaliwungu Village, Ngombol District, Purworejo

Karnoto
Dept. of Electrical Engineering, Diponegoro University, Semarang, Indonesia

Pangestuningtyas Diah Larasati
Electrical Engineering, Politeknik Negeri Semarang, Semarang, Indonesia

Friska Ayu Fitrianti Sugiono
Mechanical Engineering, Politeknik Negeri Semarang, Semarang, Indonesia

Faisal Akmal Zulhusni
Dept. of Industrial Engineering, Diponegoro University, Semarang, Indonesia

Published Date: June 02, 2026 **Article DOI : 10.65150/EP-gjetr/V2E6/2026-01**

ABSTRACT: The majority of the population in Kaliwungu Lor Village, Purworejo District work as farmers. The irrigation system in the village generally still uses semi-technical irrigation and rainfed paddy fields. In the dry season, rainfed fields often experience difficulties in producing paddy due to the difficulty of water for irrigation. In 2020, the Provincial Government of Central Java provided assistance in the form of a Solar Water Pumps Systems (SWPS) with a capacity of 11 kWp to irrigate 15 hectares of paddy fields. The system is expected to distribute water from the Kranjang River to agricultural land in Kaliwungu Lor Village during the dry season. This study examines the effect of SWPS installation on the economic conditions of farmers in Kaliwungu Lor Village. The research used a survey method with a quantitative approach. A paired sample t-test was conducted to evaluate the statistical significance of operational cost differences before and after the implementation of the SWPS. The analysis was carried out at a 95% confidence level with a significance threshold of $p<0.05$. Based on the results of the research conducted, the construction of SWPS in Kaliwungu Lor Village can increase the harvest period for farmers, which was originally 2 times/year to 3 times/year, there are 108 tons/year. In addition, the SWPS reduced operational costs previously spent on diesel fuel for irrigation pumps during the dry season. Farmers saved Rp 37.311.750/per planting period in 2020-2021 and Rp 49.266.000/per planting period from 2022-2025.

KEYWORDS: irrigation, photovoltaic, solar water pumping systems, economy of farmers

INTRODUCTION

Solar Water Pumps Systems (SWPS) have been used from 1964 – 1966 until now, many journals discuss SWPS development, operating systems, and optimization, this was studied and reviewed by Olga V. Shepovalova, et al (Shepovalov et al., 2020) (Pratilastiarso et al., 2021). Rosa J. Chilundo, et al researched the mathematical design of the potential use of electrical energy for irrigation and to supply water needs in horticultural crops with various growth phases by studying the case of the capsicum plant in Mozambique (Chilundo et al., 2019). They also discussed the use of SWPS for irrigation as a green energy strategy to increase food production, so that it can increase social and economic growth and even increase the green economy in Mozambique (Arifin et al., 2020). SWPS can also be used and developed as an irrigation system for sugar cane farmers in Australia, where this has been researched by J.W. Powell, et al (Powell et al., 2017). Many researchers have created analysis software or mathematical methods to improve SWPS optimization to help meet water or irrigation needs, one of which is Sergio Gualteros and Daniel R. Rousse who discuss open access software for rural communities with off-grid systems (Gualteros & Rousse, 2021). Pushpendra Kumar Singh Rathore, et al even discussed policies that could be implemented by the Government to increase the use of SWPS in the agricultural sector in India and could even be implemented globally (Rathore et al., 2018) (Vishnupriyan et al., 2022). This is because SWPS can replace diesel water pumps that use fossil fuels as an excess, and can reduce carbon dioxide emissions caused by the use of diesel engines. Even PATS also has feasibility in the financial sector when compared to the use of diesel water pumps.

Kaliwungu Lor Village is one of the villages in Ngombol District, Purworejo Regency, Central Java, where ± 90% of the population work as farmers. According to data from Statistics Indonesia in Purworejo District, Ngombol District in Figures 2019, the area of paddy fields in Kaliwungu Lor Village reaches 76.66 Ha. Agriculture in Kaliwungu Village is still classified as simple agriculture, this can be seen that the management of paddy field irrigation still uses a semi-technical irrigation system (60.00 ha) and rainfed paddy fields (16,66 ha).

License: This is an open access article under the CC BY 4.0 license: https://creativecommons.org/licenses/by/4.0/

Rainfed paddy fields are paddy fields that only rely on rainfall to irrigate their fields so that during the dry season rainfed paddy fields tend to dry up and cannot even produce paddy. In Kaliwungu Lor Village, the irrigation system for rain-fed paddy fields during the dry season uses solar-powered water pumps to distribute water from the Kranjang River to the paddy fields. The use of water pumps with diesel power can increase the operational costs of farmers in Kaliwungu Lor Village (Vishnupriyan et al., 2022).

In 2020, the Provincial Government of Central Java, in this case, the Mineral Resources Energy Service of Central Java Province, will assist the Village of Kaliwungu Lor Solar Water Pumps Systems (SWPS) with a solar panel capacity of 11 kWp (Obalalu et al., 2023). SWPS is a water pump that uses a solar power supply with the help of solar panels to irrigate paddy fields, especially during the dry season. The government hopes that this SWPS can help farmers to reduce the cost of producing paddy fields, increase the planting season, and increase the use of new renewable energy in Central Java as environmentally friendly energy. This study aims to determine the effect of the installation of SWPS for irrigation systems on improving the economy of the people in Kaliwungu Lor Village (ENID, n.d.).

LITERATURE REVIEW

Solar Water Pumping Systems (SWPS) is a water pump that uses a solar power supply. Solar power loosens up into unidirectional electricity by using solar panels (Shyam & Kanakasabapathy, 2022) (Bucur & Isbăşoiu, 2008). A solar water pump is one application in the utilization of solar power as an alternative energy that is environmentally friendly (Sianipar, 2017). The advantage of using SWPS for irrigating paddy fields is that it helps farmers to reduce operational costs due to the use of solar-fueled water pumps, the construction is relatively easy, especially near paddy fields which are usually located far from the PLN electricity network, maintenance, and maintenance of SWPS is also relatively easy and inexpensive. In addition, the solar panels used as a SWPS energy source produce environmentally friendly energy. The drawback is that the power generated tends to be unstable according to the intensity of the sun and the temperature received by the solar panel (Ma et al., 2024).

MATERIALS AND METHODS

The government in Kaliwungu Lor Village, Ngombol District, Purworejo Regency received assistance from the Central Java Provincial Government in the form of PATS with a capacity of 11 kWp to irrigate 15 ha of paddy fields. The type of PATS built in Kaliwungu Village is a PATS without batteries, so irrigation needs can only be fulfilled during the day in sunny conditions. The source of water used as a source of irrigation is the Kranjang River Dam. The irrigation water pump used is a submersible sewage centrifugal pump with a capacity of 8,162 kW and a design head of 7 meters, the amount of water discharge that can be produced per day is 1.080 m^3 per day.



Figure 1. PV 11 kWp as a supply pump



Figure 2. Water pump submersible type 8,162kW

The method of conducting research carried out to determine the effect of installing SWPS on improving the economy of farmers in Kaliwungu Village, Ngombol District uses a quantitative research method based on survey results at the research location. The survey will be carried out in 2025 when the use of PATS in Kaliwungu Village has been felt by farmers for about 5 years. A paired sample t-test was conducted to evaluate the statistical significance of operational cost differences before and after the implementation of the Solar water Pumping Systems (SWPS). The analysis was performed at a 95% confidence level with a significance threshold of $p < 0.05$.

RESULTS

Influence on Sales Results Production of Harvested Dry Grain (GKP)

SWPS is an irrigation pump that uses solar energy as its prime-over source (Maulidyna et al., 2021). All regions in Indonesia are areas with very high potential to use solar energy as renewable energy because the level of solar intensity is relatively constant throughout the year and is large. Photovoltaic is very suitable for use in the dry season because the intensity of the sun is greater than in the rainy season (Shofi et al., 2023). SWPS installation in Kaliwungu Lor Village, Ngombol District, Purworejo Regency, Central Java can increase the paddy planting period from 2 (two)

License: This is an open access article under the CC BY 4.0 license: https://creativecommons.org/licenses/by/4.0/

times per year to 3 (three) times per year. Based on the results of interviews conducted with farmers on site, it was found that a paddy field with an area of 1 ha can produce about 72 quintals of grain. The magnitude of the increase in crop production in Kaliwungu Lor Village can be calculated by the equation below.

$$Paddy\ production = paddy\ field\ area \times 72\ quintal/ha \quad (1)$$

Where paddy field area is the area of paddy fields in hectares, and Σ production/ha is the amount of grain production that can be produced per 1 hectare of paddy fields.

By using equation (1) the result is that the grain products that can be produced by a 15 ha paddy field in Kaliwungu Lor Village is 108 tons in one harvest. The use of PATS can increase the number of harvests per year from 2 times per year to 3 times per year, resulting in an increase in grain production in a year as much as 108 tons of grain per year. The following is a comparative graph of the effect of the average selling price of grain per year in Kaliwungu Lor Village, Ngombol District before and after the SWPS development.

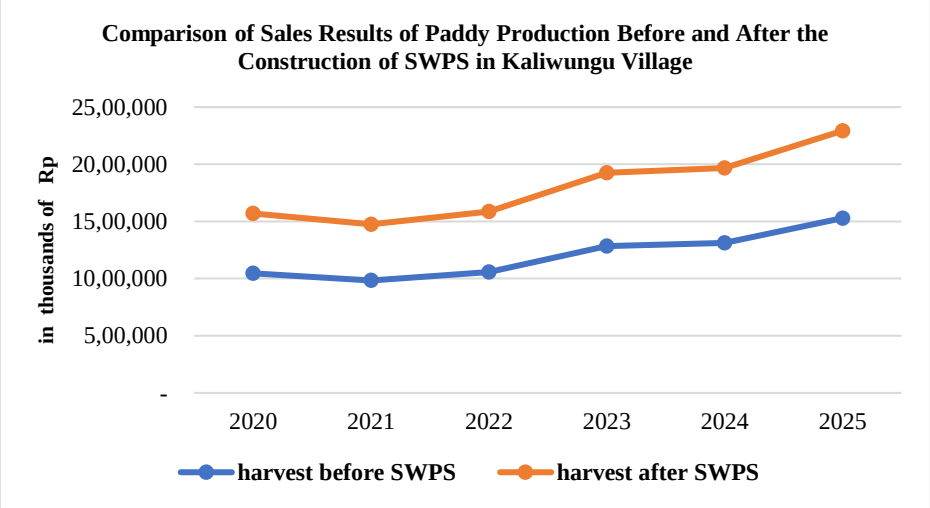


Figure 3. Graph of Comparison of Selling Paddy Production Results Before and After Development of SWPS in Kaliwungu Lor Village

Table 1. Average Sales of Dry Grain Before and After the Establishment of SWPS

Year	Average Sales of Dry Grain (in thousand Rupiah)	
	Harvest before SWPS	Harvest after SWPS
2020	1.046.493	1.569.740
2021	983.182	1.474.772
2022	1.057.465	1.586.198
2023	1.282.716	1.924.074
2024	1.312.187	1.968.280
2025	1.528.650	2.292.975

Influence on Saving Operational Costs for Processing Paddy Fields

Before there is construction of SWPS in Kaliwungu Lor Village, during the dry season the need for irrigating rainfed paddy fields was assisted by a diesel water pump using diesel as the prime over source. The diesel water pump functions to help collect and distribute water from the Kranjang River to the rainfed paddy fields in the vicinity. The diesel water pump for the irrigation system in Kaliwungu Lor Village is operated 24 hours per day for one week in a row. The break period from using diesel pumps for irrigation systems is only 3 days, after which they operate 24 hours a day for one week. This operating cycle repeats continuously until harvest time arrives. The paddy planting period in Kaliwungu Village is approximately 3 months.

In Kaliwungu Lor Village, there are 3 diesel pumps used for irrigating the western paddy fields, and 1 diesel pump for the eastern pump. The amount of fuel needed to power the diesel water pump in Kaliwungu Lor Village is 23 liters/pump/day. The use of diesel pumps to assist the irrigation system in Kaliwungu Lor Village adds to the operational cost burden for farmers. The potential savings that can be made by farmers due to the replacement of diesel pumps with SWPS for irrigation systems during the dry season can be calculated using the following equation.

$$Savings\ (Rp) = fuel\ oil\ prices \times fuel\ oil\ requirement\ per\ planting\ period \quad (2)$$

Based on the results of a survey conducted with farmer groups in Kaliwungu Lor Village, a minimum of 5 diesel water pumps are used during the dry season. The potential for operational cost savings with the construction of SWPS in Kaliwungu Lor Village in 2020 – 2025 can be seen in the table below.

License: This is an open access article under the CC BY 4.0 license: https://creativecommons.org/licenses/by/4.0/

Table 2. Potential Savings in Operational Costs by Using SWPS

Savings per planting period (Rp)	2020	2021	2022	2023	2024	2025
	37.311.750	37.311.750	49.266.000	49.266.000	49.266.000	49.266.000

DISCUSSION

Influence on Sales Results Production of Harvested Dry Grain (GKP)

Based on the Fig. 3 and Table 1, it can be seen that the use of SWPS in Kaliwungu Lor Village can increase the production of harvested dry grain. The selling price of harvested dry grain per month that can be produced by farmers in Kaliwungu Lor Village after an increase in the harvest period due to the construction of a SWPS with a capacity of 11 kWp can be seen in the figure below. The selling price of harvested dry grain in 2020 – 2025 is based on the Average Monthly Unhusked Rice Price by Quality, Quality Components, and GPP at the Farmer Level taken from Indonesian statistical survey agency (Badan Pusat Statistik [BPS], 2025) (Vishnupriyan et al., 2022) (Obalalu et al., 2023).

Development of SWPS in Kaliwungu Lor Village can increase the harvest period for farmers. This is due to the fact that during the dry season, farmers' paddy fields that use rain-fed irrigation systems can still get irrigation from the Kranjang River so even during the dry season the paddy fields in Kaliwungu Lor Village can still produce. The construction of SWPS in Kaliwungu Lor Village will begin in 2020. The implementation of SWPS in Kaliwungu Lor Village led to a 50% increase in farmers' income compared to the period prior to the adoption of SWPS according to Fig.1 and Table 1 The selling price of dry grain is strongly influenced by the monthly selling price set by the government.

Influence on Saving Operational Costs for Processing Paddy Fields

Based on the Table 2, it can be seen that there is an increase in savings that can be implemented by farmers with the use of SWPS as an irrigation system in Kaliwungu Lor Village. In Table 2, it can be seen that the use of an irrigation system using SWPS is feasible to be considered for use and can help farmers in Kaliwungu Lor Village. Since 2022, the implementation of SWPS has led to a reduction in operational costs for diesel fuel used by irrigation pumps during the dry season, with savings reaching up to IDR 49,266,000 per planting season. The trend of rising fuel oil in Indonesia will increase gradually, this is because the Government will gradually reduce subsidies for fuel oil. Therefore, the use of SWPS is proposed as an alternative to diesel pumps for the irrigation system in Kaliwungu Lor Village.

CONCLUSION

The use of SWPS as an irrigation system in Kaliwungu Lor Village, Ngombol District, Purworejo Regency, Central Java is very helpful for farmers in the village. Farmers can reduce production costs by purchasing diesel fuel which is usually used in the dry season to help irrigate their fields. In addition, the use of SWPS can also increase the harvest period for farmers in Kaliwungu Lor Village, from only 2 harvest times a year to 3 harvest times a year.

The SWPS built by the Provincial Government of Central Java still uses a system without a battery, so to increase the reliability of the SWPS in Kaliwungu Lor Village, SWPS should be equipped with batteries. In addition, there is a need for training of technical personnel for the operation and maintenance of SWPS in Kaliwungu Lor Village so that SWPS can be continuously used and utilized by farmers in Kaliwungu Lor Village.

ACKNOWLEDGMENT

This research is collaboration between Diponegoro University and Semarang State Polytechnic.

REFERENCES

1) O. V. Shepovalov, A. T. Belenov, and S. V. Chirkov, "Review of photovoltaic water pumping system research," *Energy Reports*, vol. 6, no. April, pp. 306–324, 2020, doi: 10.1016/j.egyr.2020.08.053.
2) J. Pratilastiarso, L. Diana, E. Tridianto, and A. G. Safitra, "Pemasangan Smart Solar Water Pump Sebagai Alat Irigasi Sawah Di Desa Gayam Kabupaten Bojonegoro," *J. Pengabdi. Kpd. Masy.*, vol. 27, no. 1, p. 21, 2021, doi: 10.24114/jpkm.v27i1.20801.
3) R. J. Chilundo, D. Neves, and U. S. Mahanjane, "Photovoltaic water pumping systems for horticultural crops irrigation: Advancements and opportunities towards a green energy strategy for Mozambique," *Sustain. Energy Technol. Assessments*, vol. 33, no. March, pp. 61–68, 2019, doi: 10.1016/j.seta.2019.03.004.
4) Z. Arifin, A. J. Tamamy, and N. Islahu, "Perancangan Mesin Pompa Air Tenaga Surya untuk Mengurangi Konsumsi Listrik Skala Rumahan," *J. Nas. Tek. Elektro*, vol. 9, no. 2, p. 79, 2020, doi: 10.25077/jnte.v9n2.758.2020.
5) K. M. Powell, K. Rashid, K. Ellingwood, J. Tuttle, and B. D. Iverson, "Hybrid concentrated solar thermal power systems: A review," *Renew. Sustain. Energy Rev.*, vol. 80, no. January, pp. 215–237, 2017, doi: 10.1016/j.rser.2017.05.067.
6) S. Gualteros and D. R. Rousse, "Solar water pumping systems: A tool to assist in sizing and optimization," *Solar Energy*, vol. 225. pp. 382–398, 2021. doi: 10.1016/j.solener.2021.06.053.
7) P. K. S. Rathore, S. S. Das, and D. S. Chauhan, "Perspectives of solar photovoltaic water pumping for irrigation in India," *Energy Strateg. Rev.*, vol. 22, no. December 2017, pp. 385–395, 2018, doi: 10.1016/j.esr.2018.10.009.
8) J. Vishnupriyan, P. Partheeban, A. Dhanasekaran, and M. Shiva, "Analysis of tilt angle variation in solar photovoltaic water pumping system," *Mater. Today Proc.*, vol. 58, pp. 416–421, 2022, doi: 10.1016/j.matpr.2022.02.353.
9) A. M. Obalalu *et al.*, "Thermal performance of Oldroyd-B hybrid nanofluid in solar energy-based water pumping systems and entropy generation minimization," *Case Stud. Therm. Eng.*, vol. 51, no. September, p. 103476, 2023, doi: 10.1016/j.csite.2023.103476.
10) ENID (Egypt Network for Integrated Development), "Solar Water Pumps: The Case of Egypt's Desert, Case Study 013", [Online]. Available: http://enid.org.eg/uploads/PDF

License: This is an open access article under the CC BY 4.0 license: https://creativecommons.org/licenses/by/4.0/

11) B. Shyam and P. Kanakasabapathy, “Feasibility of floating solar PV integrated pumped storage system for a grid-connected microgrid under static time of day tariff environment: A case study from India,” *Renew. Energy*, vol. 192, pp. 200–215, 2022, doi: 10.1016/j.renene.2022.04.031.
12) D. M. Bucur and E. C. Isbăşoiu, “Air pockets in pipeline systems,” *UPB Sci. Bull. Ser. D Mech. Eng.*, vol. 70, no. 4, pp. 35–44, 2008.
13) R. Sianipar, “Dasar Perencanaan Pembangkit Listrik Tenaga Surya,” *Jetri J. Ilm. Tek. Elektro*, vol. 11, pp. 61–78, 2017, doi: 10.25105/jetri.v11i2.1445.
14) Y. Ma, J. Xi, J. Cai, and Z. Gu, “The optimization and energy efficiency analysis of a multi-tank solar-assisted air source heat pump water heating system,” *Therm. Sci. Eng. Prog.*, vol. 48, no. December 2023, p. 102387, 2024, doi: 10.1016/j.tsep.2024.102387.
15) A. MAULIDYNA *et al.*, “Review: Economic impacts of the invasive species water hyacinth (Eichhornia crassipes): Case study of Rawapening Lake, Central Java, Indonesia,” *Int. J. Bonorowo Wetl.*, vol. 11, no. 1, pp. 18–31, 2021, doi: 10.13057/bonorowo/w110103.
16) A. A. Shofi, S. Sulistiyanto, and M. Bachrudin, “Rancang Bangun Water Pump Solar Energy Portable Perairan Sawah Untuk Membantu Petani Kabupaten Probolinggo,” *Med. Tek. J. Tek. Elektromedik Indones.*, vol. 4, no. 2, pp. 79–86, 2023, doi: 10.18196/mt.v4i2.16035.
17) B. P. Statistik, “Rata-rata Harga Gabah Bulanan Menurut Kualitas, Komponen Mutu dan HPP di Tingkat Petani.”
18) Shofi, A. A., Sulistiyanto, S., & Bachrudin, M. (2023). Rancang bangun water pump solar energy portable perairan sawah untuk membantu petani Kabupaten Probolinggo. Med. Tek. Jurnal Teknik Elektromedik Indonesia, 4(2), 79–86. https://doi.org/10.18196/mt.v4i2.16035

License: This is an open access article under the CC BY 4.0 license: https://creativecommons.org/licenses/by/4.0/