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Application of Hybrid Power Plants Photovoltaic and Picohydro as Utilization of Overflow Water Sources

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The design and application of research on renewable energy has been widely used. Several studies on solar power plants that discuss energy efficiency, system optimization, even design using artificial intelligence. But solar panels are greatly affected by the ever-changing weather and climate. Several studies on hydroelectric power plants are also the same. So a hybrid system is needed to overcome this problem. Researchers apply by trying to combine the two generators by utilizing the overflow of source water. Because the water discharge is small and the height of the fall is low, an axil flow turbine generator is used as a power plant. To combine these two generators, an On grid or Grit tie inverter is used. From the research results, it was found that the hybrid picohydro power plant and solar panels have met the electricity load needs, the generating power is greater than the daily load power. The output power of the hybrid generator has met the daily load needs. The average load power is 1088.86/day and the average power of the hybrid generator is 1468.88 W/day. This research will be developed using a hybrid solar panel system. So that water sources with small discharges can be used more optimally.

Keywords: hybrid power plant, photovoltaic, picohydro, overflow, solar panel.

1. Introduction

Renewable energy that comes from nature is very necessary to replace fossil energy. One of them is hydroelectric power plants and solar power plants also called photovoltaics or solar panels.. Hydroelectric power plant is a power plant that utilizes the potential energy of water, which is converted into electrical energy and the Solar Power Plant is a power plant that utilises energy from sunlight to produce electrical energy. The capacity of hydroelectric power plant with a power of less than 5 kW is categorised as picohydro. Pico Hydro with axial turbines is a hydroelectric power plant that utilizes a flow with a small water discharge and a low fall height. By utilizing natural resources, it is necessary to build a hybrid power plant. In this case, the solar power plant with a pico hydro power plant uses an axial turbine with a power of 2kW. Solar Power Plants are used to meet energy needs during the day and electrical energy efficiency(Eswanto, Hasan and Razlan, 2023).

Previous research has studied Coal-fired Power Plant, microhydro power plant, and photovoltaic separately. It has also been studied about water flow with various methods. Photovoltaic Power Plants; Machrus Ali previous research discussed comparing dual axis photovoltaic optimization using various types of artificial intelligence (Ali, Firdaus, et al., 2021). Machrus Ali discusses photovoltaic optimization using PID control with the firefly algorithm determination method (Ali et al., 2022). Waleed Mohammed Khazaal discusses the simulation of the impact of several climate and technical variables on inverter losses, power generation production, and capacity factors (Khazaal et al., 2024). Hydro Power Plant; Machrus Ali researched the optimization of microhydro using frequency control (Ali, Djalal, et al., 2021). Akhiriyanto Pratama researched the collection of energy from Pico Hydro Power Plants in the PEM Akamigas Solar Power Pump (PEMASOL) research (Pratama, Akhiriyanto and A, 2023). He Li et al discussed Complementary operation of large-scale hydro-photovoltaic (PV) hybrid power plants. (Li et al., 2019). Ramadoni Syahputra, discusses the planning of a small-scale hybrid microhydro and solar photovoltaic system for rural areas in Central Java, Indonesia (Syahputra and Soesanti, 2020).

From the research and discussion of previous researchers, no one has studied the hybrid picohydro power plant from overflow water sources. This research is important because it can be used in small water flows using axial turbines. Axial water turbines require small water discharge with relatively low fall heights (Li et al., 2019).

2. Case and Methodology

A. Solar Power Plant

The solar power plant in this study uses Mono-crystalline PV half-cut cell modules with a power of 450 W. Electrical specifications: Nominal Max Power 450 Wp; Max operating voltage 41.40 V; Max operating current 10.87 A; Open circuit voltage 50.0 V; Short-circuit current 11.54 A. The PV (Photovoltaic) module is connected to an On-Gid (Grid tie) inverter and combined with the output of the Axial Flow Turbine Generator.

B. Hydroelectric Power Plant (Pico Hydro)

Hydroelectric Power Plant (Pico Hydro) uses Axial Flow Turbine Generator as a driver with Micro Permanent Magnet with Kaplan turbine type. Kaplan turbine have a blade rotating structure, called guide vanes or wicket gates, inside the turbine runner, which can rotate comparatively to the runner. In this study, an axial flow turbine was used because it can be used in water flows with small discharge and low fall height. At the research location, the water discharge was only 1.3 liters/second with a fall height of 5 meters. So the axial flow was chosen with a power capacity of 2kW. Technical parameters: Model: ZD760-LM-10-25 permanent magnet hydro turbine generator unit; Phase: single-phase/three phase; Voltage: 220V AC; Nominated power: 2.0KW; Water head: 1meters to 5 meters; Water flow: 0.02 - 1.0 m3/s (20 Liters/s-1000 Liters/s); Available working environment temperature: -10°C - +60°C; Working type: continuous. The axial flow turbine display can be seen in Figure 1.

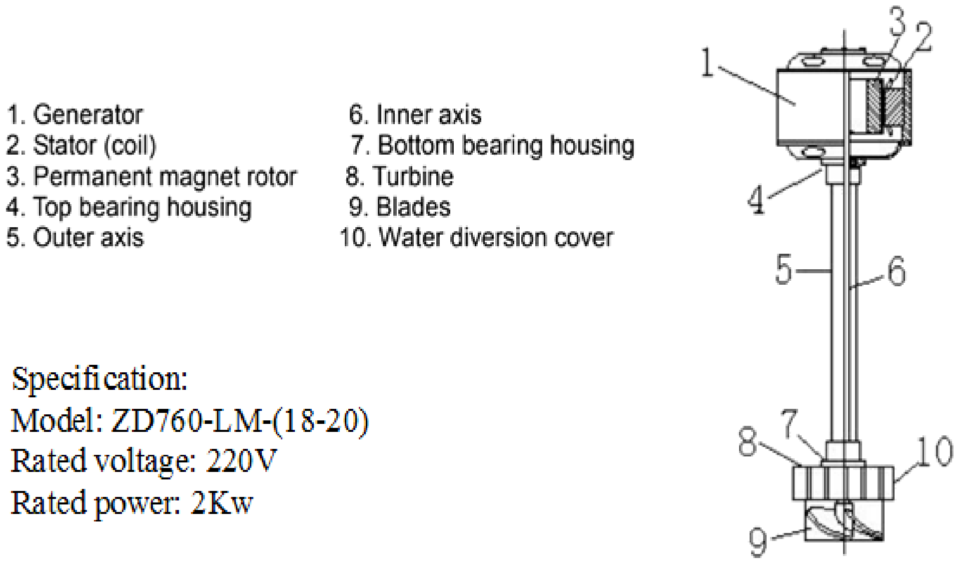

Figure 1. The axial flow turbine.

C. Hybrid Power Plant

The realization of a hybrid power plant using hydropower (picohydro) and solar power (photovoltaic) can be seen in Figure 2.

Figure 2. Desain a hybrid power plantt

The research flow chart can be seen in figure 1.

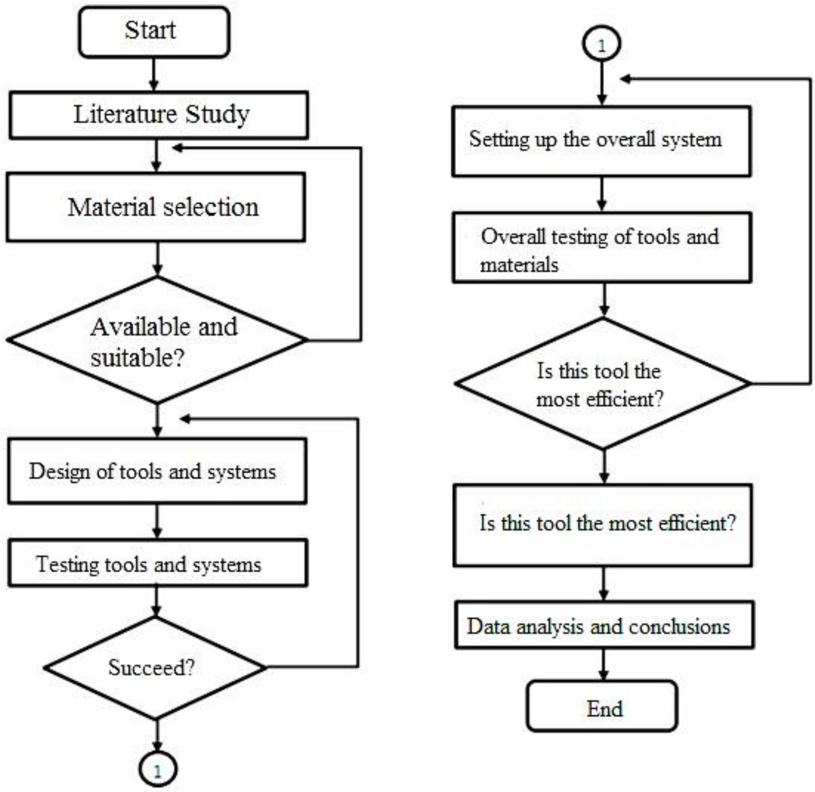

Figure 3. The research flow chart

3. Results and Discussion

Weather greatly affects the output power, voltage, and current of solar panels. This causes the output power value produced to vary, depending on the intensity of sunlight hitting the surface of the panel. If the solar panel is not covered by shadows or clouds, the intensity of sunlight will affect the voltage and current values produced. The higher the intensity of sunlight, the greater the voltage and current produced by the solar panel. The characteristics of this solar panel show that the output power produced depends on the intensity of light hitting the surface of the panel. Power, current, and voltage can be seen in figures 2, 3, and 4.

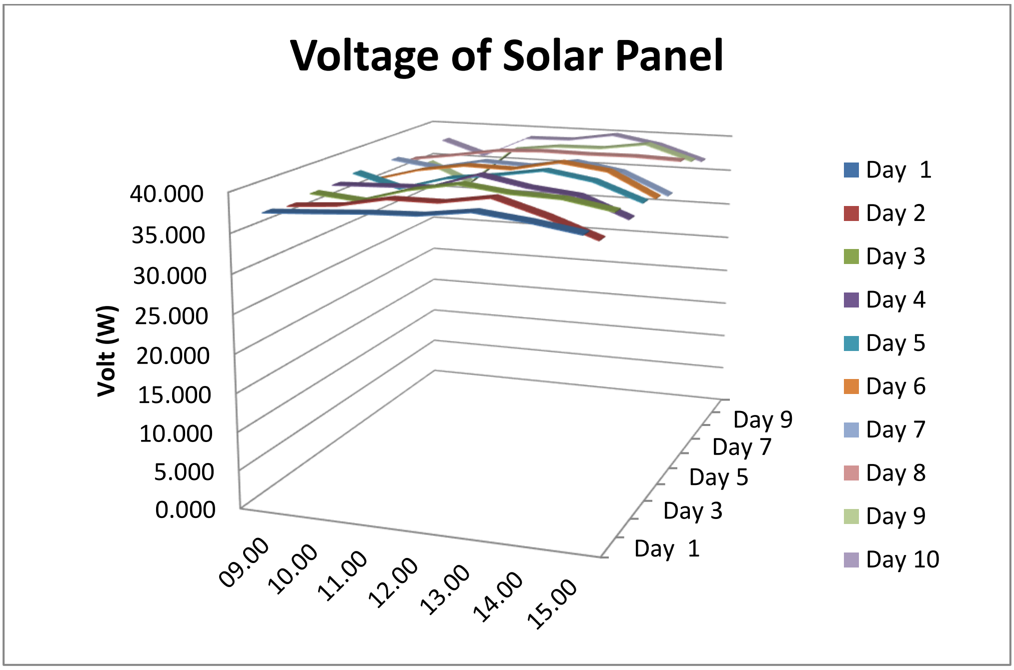

Figure 4. Voltage (V) of solar panel over 10 days

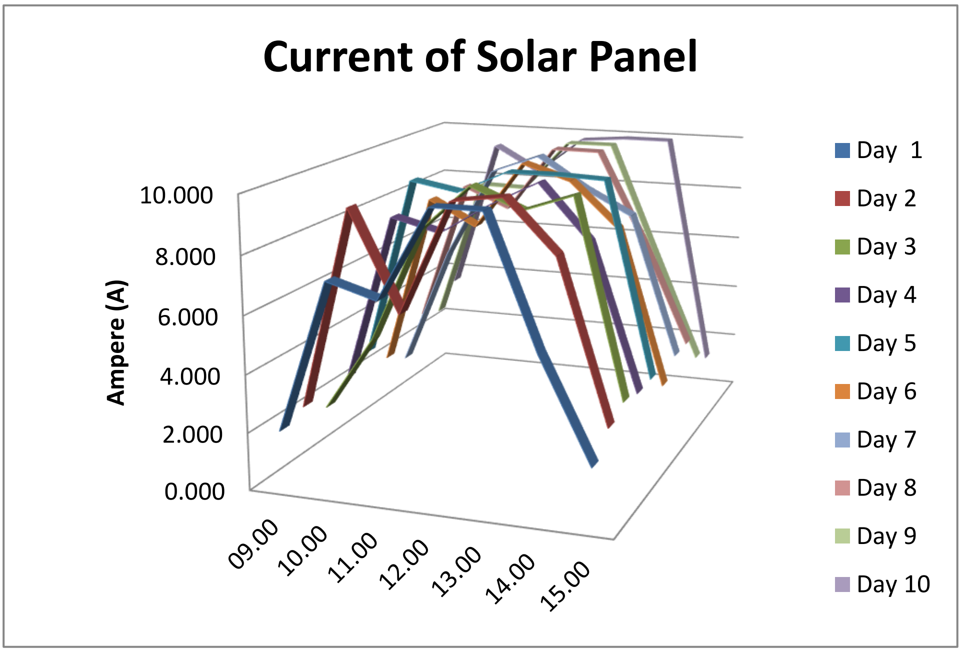

Figure 5. Current (A) of solar panel over 10 days

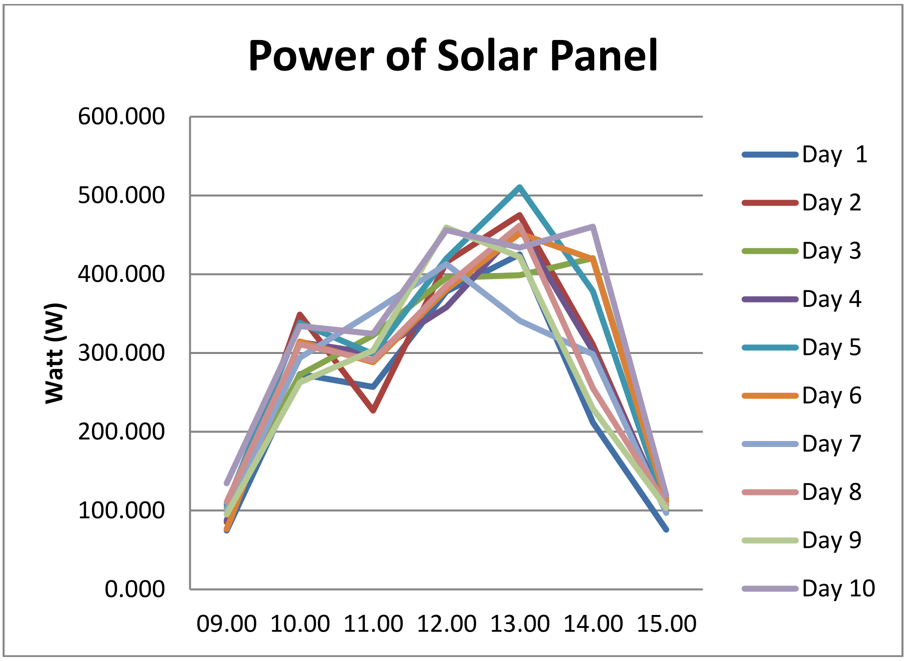

Figure 6. Power (W) of solar panel over 10 days

The output power of picohydro, solar panels, and hybrid generators in 10 full days can be seen in figures 5 and 6.

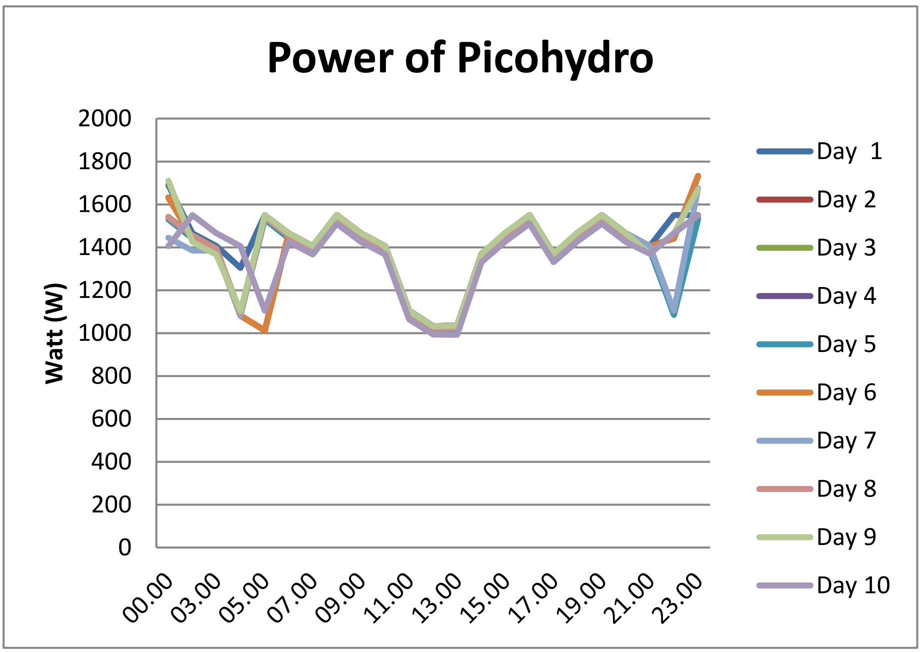

Figure 7. Power (W) of pico hydronel over 10 days

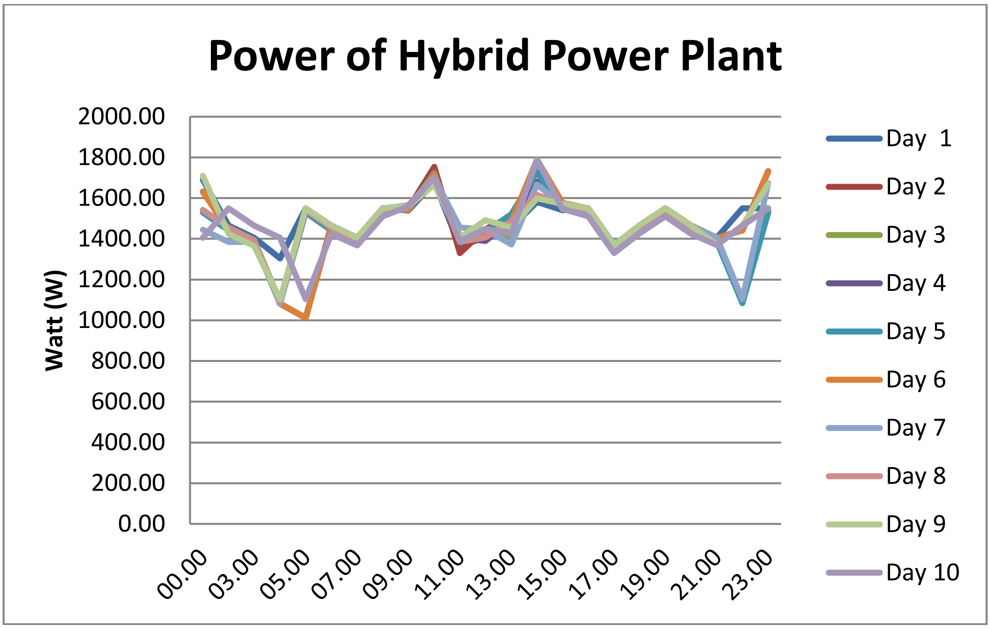

Figure 8. Power (W) of Hybrid Power Plant over 10 days

The average profiles of the load, picohydro power, solar panel power, and hybrid generator power for 10 full days can be seen in Figure 7 and Table 2.

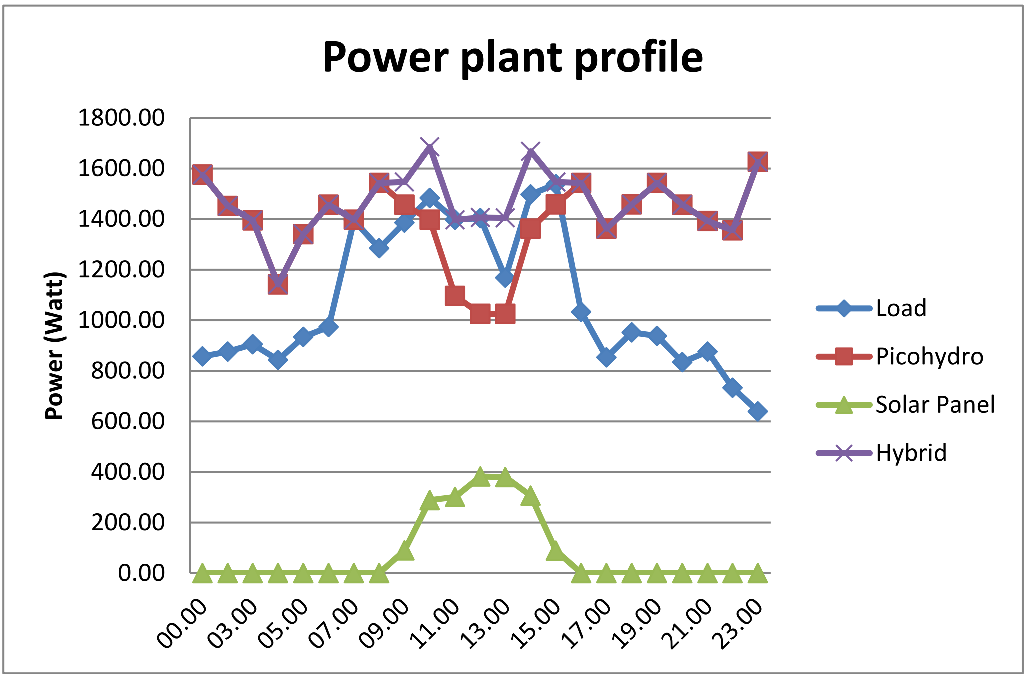

Figure 9. The average profile Power Plant over 10 full days

Table 1. The average profile Power Plant over 10 full days

Time	Load (W)	Pico hydro (W)	Solar Panel (W)	Hybrid (W)
00.00	856.43	1575.70	0.00	1575.70
01.00	875.49	1450.80	0.00	1450.80
03.00	904.55	1394.80	0.00	1394.80
04.00	843.03	1140.90	0.00	1140.90
05.00	934.54	1340.20	0.00	1340.20
06.00	973.82	1456.60	0.00	1456.60
07.00	1394.59	1397.00	0.00	1397.00
08.00	1284.52	1542.20	0.00	1542.20
09.00	1386.01	1456.60	89.70	1546.30
10.00	1483.63	1397.00	287.91	1684.91
11.00	1397.73	1095.60	304.51	1400.11
12.00	1643.62	1024.30	408.91	1433.21
13.00	1168.55	1025.10	437.93	1463.03
14.00	1497.74	1362.00	317.01	1679.01
15.00	1538.65	1457.50	88.92	1546.42
16.00	1032.87	1542.00	0.00	1542.00
17.00	853.46	1362.00	0.00	1362.00
18.00	952.39	1457.50	0.00	1457.50
19.00	937.93	1542.20	0.00	1542.20
20.00	834.65	1456.60	0.00	1456.60
21.00	876.23	1391.70	0.00	1391.70
22.00	733.79	1354.80	0.00	1354.80
23.00	639.64	1626.30	0.00	1626.30
Max	1643.62	1626.30	437.93	1684.91
Min	639.64	1024.30	0.00	1140.90
Average	1088.86	1384.76	84.13	1468.88

4. Conclusion

From the research results obtained maximum load power of 1643.62 W, minimum power of 639.64 W, average power of 1088.86 W. The maximum power of the hybrid generator is 1684.91 W, minimum power of 1140.90 W, and average power of 1468.88 W. This shows that the hybrid picohydro and solar panel power plants have met the needs of the electrical load. The output power of the hybrid generator has met the daily load needs. The average load power is 1088.86 W and the average power of the hybrid generator is 1468.88 W. But the maximum load power is 1643.62 W while the minimum power of the hybrid generator is 1140.90 W, so the addition of solar panels is needed.

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References

1. Ali, M., Djalal, M.R., et al. (2021) 'Application of Energy Storage-PID For Load Frequency Control In Micro-hydro Using Flower Pollination Algorithm', in 2021 3rd International Conference on Research and Academic Community Services (ICRACOS). IEEE, pp. 281–285. Available at: https://doi.org/10.1109/ICRACOS53680.2021.9702063.
2. Ali, M., Firdaus, A.A., et al. (2021) 'The comparison of dual axis photovoltaic tracking system using artificial intelligence techniques', IAES International Journal of Artificial Intelligence (IJ-AI), 10(4), p. 901. Available at: https://doi.org/10.11591/ijai.v10.i4.pp901-909.
3. Ali, M. et al. (2022) 'Determination of the parameters of the firefly method for PID parameters in solar panel applications', SINERGI, 26(2), p. 265. Available at: https://doi.org/10.22441/sinergi.2022.2.016.
4. Eswanto, E., Hasan, H. and Razlan, Z.M. (2023) 'An Analysis on Performance of Pico-hydro with Archimedes Screw Model Viewed from Turbine Shaft Angle', International Journal of Engineering, Transactions A: Basics, 36(1), pp. 10–18. Available at: https://doi.org/10.5829/ije.2023.36.01a.02.
5. Khazaal, W.M. et al. (2024) 'The Losses of Inverters and Off-Grid Photovoltaic Power Plants Efficiency Nexus Evaluation in Iraqi Region', Nanotechnology Perceptions, 20(S2), pp. 729–744. Available at: https://doi.org/10.62441/nano-ntp.v20iS2.54.
6. Li, H. et al. (2019) 'Long-term complementary operation of a large-scale hydro-photovoltaic hybrid power plant using explicit stochastic optimization', Applied Energy, 238, pp. 863–875. Available at: https://doi.org/10.1016/j.apenergy.2019.01.111.
7. Pratama, A., Akhiriyanto, N. and A, W.W. (2023) 'Design and Development of Maximum Power Point Tracking for Picohydro in Renewable Energy Harvesting Hybrid Systems', Indonesian Journal of Energy and Mineral, 3(2), pp. 117–128. Available at: https://doi.org/10.53026/ijoem/2023/3.2/1170.
8. Syahputra, R. and Soesanti, I. (2020) 'Planning of hybrid micro-hydro and solar photovoltaic systems for rural areas of central Java, Indonesia', Journal of Electrical and Computer Engineering, 2020. Available at: https://doi.org/10.1155/2020/5972342.