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Energy Efficiency of Solar and Hydroelectric Hybrid Power Plant for Overflow Water

Abstract: - Hybrid power plants using hydropower and solar power are starting to be used and utilized with various technological innovations. Studying the optimization and efficiency of solar panels, including partial shading, dial-axis photovoltaics, and artificial intelligence-based solar panel comparisons, is crucial. Hydroelectric power plants focus on optimizing their AVR (Automatic Voltage Regulator), LFC (Load Frequency Control), and employing artificial intelligence for this purpose. The importance of the solar charge controller (SCC), automatic transfer switch (ATS), and coordination of low voltage disconnect (LVD) has not been taken into consideration in previous studies. The study's findings demonstrate that Pico Hydro energy production and solar panels with SCC, ATS, and LVD coordination efficiently meet all energy needs. This hybrid hydroelectric and solar power plant employs an axial flow turbine with a power output of 2 kW and a 450 Wp solar panel. The output power of the hydroelectric power plant (pico-hydro) is always constant, while the output power of the solar power plant is very fluctuating, with a current output power of 6.34 amperes and a voltage of 28.72 volts in cloudy weather conditions. This study yields energy output that surpasses the load requirements and can effectively fuel energy consumption in the surrounding area. We can use the results of this study to develop other hydropower and solar power plants.

Keywords: Hybrid Power Plant, Overflow water Sourse, Efficiency Energi, Solar Panel, hydroelectric

1. INTRODUCTION

Several previous studies have discussed the optimization and efficiency of solar panels, including partial shading solar panels[1], dual axis photovoltaics[2][3], and comparison of solar panels using artificial intelligence[4][5]. The purpose of this study is to analyze the performance of solar panels under various conditions and make recommendations for improving their efficiency. Several studies also discuss the optimization and efficiency of hydroelectric power plants, including the optimization of AVR (Automatic Voltage Regulator)[6], LFC (Load Frequency Control), and optimization using artificial intelligence[7].

Energy efficiency enhances the reliability and resilience of the grid, ensuring a stable energy supply for consumers. Prioritizing energy efficiency in power plant operations is crucial to meet the energy demands of society, reduce the impact of climate change, and contribute to economic growth and job creation in renewable energy. Hybrid power plants combine solar and hydroelectric energy to enhance energy efficiency and sustainability. This power plant provides a consistent and reliable source of electricity, thereby reducing greenhouse gas emissions. This power plant is flexible and scalable, making it suitable for various environmental conditions[8]. With technological advancements and increased investment in renewable energy, hybrid power plants can sustainably meet global energy needs, reduce carbon emissions, and contribute to energy security and grid stability. Hybrid power plants can enhance sustainability by utilizing water overflow

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from hydroelectric dams in electricity generation[9]. This excess water can be diverted to turbines, thereby increasing efficiency and reducing environmental impact. This practice maximizes the potential of renewable energy and demonstrates a commitment to sustainable practices. By harnessing water overflow, hybrid power plants can transition to a more sustainable energy future and ensure a reliable and resilient energy supply for future generations.

Solar power generation is another key component of sustainable energy practices. By harnessing the power of the sun through solar panels, electricity can be generated without emitting harmful greenhouse gases. This renewable energy source is abundant and can be utilized in various settings, from residential homes to large-scale solar farms. Solar power generation plays a crucial role in reducing reliance on fossil fuels and combating climate change. In recent years, advancements in solar technology have made it more efficient and cost-effective, making it a viable option for transitioning towards a more sustainable energy future. Solar power has the potential to revolutionize the way we generate electricity, providing a cleaner and more environmentally friendly alternative to traditional energy sources. As more and more people adopt solar energy, the demand for fossil fuels will decrease, leading to a significant reduction in carbon emissions. With ongoing research and development in the field of solar technology, we can expect even greater improvements in efficiency and affordability, paving the way for a greener and more sustainable future for generations to come. Hydroelectric power generation, a renewable energy source, can significantly reduce our reliance on fossil fuels. Large-scale hydroelectric dams provide reliable power, while smaller systems in rivers and streams offer a more sustainable solution. Advancements in technology have made hydroelectric power more efficient and cost-effective, making it an attractive option for remote or off-grid communities. As clean energy demand grows, hydroelectric power will play a crucial role in a sustainable future.

Combining hydroelectric power with solar energy can enhance its benefits by providing a reliable and consistent source of electricity. This hybrid approach minimizes environmental impact and diversifies the energy mix, ensuring a sustainable power supply. It also reduces costs associated with energy production and transmission. For example, a community near a river could install solar panels to capture sunlight and hydroelectric turbines to generate power from the flowing water. This system could reduce carbon footprints and contribute to a healthier environment. However, in areas with limited sunlight or weak water flow, alternative renewable energy sources may be necessary.

2. LITERATURE REVIEW

Several previous studies have discussed the optimization and efficiency of solar panels, including partial shading solar panels, dial axis photovoltaics, and comparison of solar panels using artificial intelligence. Several studies also discuss the optimization and efficiency of hydroelectric power plants, including the optimization of AVR (Automatic Voltage Regulator)[10], LFC (Load Frequency Control)[6][11], and optimization using artificial intelligence. However, not many have used a hybrid hydroelectric power generation system with solar power. Several previous studies are still lacking in the use of solar charge controller (SCC), automatic transfer switch (ATS), and low voltage disconnect (LVD) system coordination[12]. One example of this integration is a hybrid power system in a remote village, where a combination of hydroelectric power and solar panels are used to provide continuous and reliable electricity. By using artificial intelligence to optimize the distribution of power from both sources, the system can efficiently balance the fluctuating energy outputs and ensure a constant power supply to the community.

Solar panels capture sunlight and convert it into electricity through photovoltaic effect, capturing sunlight for homes, businesses, and community infrastructure. They can store excess electricity in batteries for low sunlight or high demand. When combined with hydroelectric turbines, this renewable energy system reduces reliance on nonrenewable resources, reducing carbon footprint and combating climate change. Governments and businesses should invest in these sustainable energy sources. Hydroelectric turbines generate power from water sources like rivers and dams by harnessing the kinetic energy of water. They convert water into mechanical energy, generating electricity. This efficient and reliable process is crucial in renewable energy systems. Investing in hydroelectric infrastructure reduces carbon footprint and creates a more resilient energy system for the future. With advancements in technology, hydroelectric power will play a larger role in a greener energy grid.One way in which hydroelectric power plants can maximize their efficiency and sustainability is by utilizing overflow water in the power generation process. When water levels in reservoirs exceed capacity, the excess water can be released through spillways or overflow channels. Instead of letting this water go to waste, hydroelectric turbines can be strategically placed to capture and harness the energy of the overflow water, further increasing the overall electricity production of the plant. This not only helps to prevent flooding and manage water levels but also maximizes the use of available resources for renewable energy generation. By incorporating overflow water into the power generation process, hydroelectric plants can operate more consistently and reliably, regardless of fluctuations in water levels. This innovative approach not only benefits the environment by reducing waste and preventing potential flooding, but also contributes to a more sustainable and efficient energy production system. By making the most of all available resources, hydroelectric power plants can continue to play a crucial role in the transition towards a cleaner, greener energy future.

3. RESEARCH METHODS

3.1. Flowchart research

The research flow diagram can be seen in Figure 1.

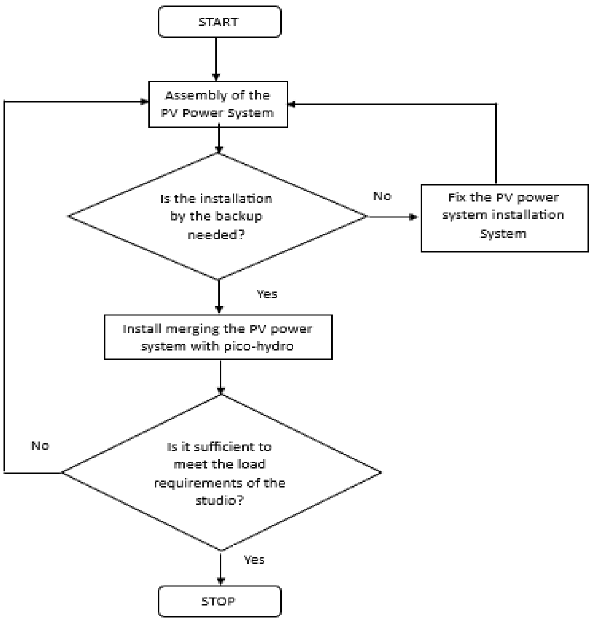


Figure 1. Flowchart Solar Power Plant

3.2. Hybrid System with Picohydro power plants and solar panels

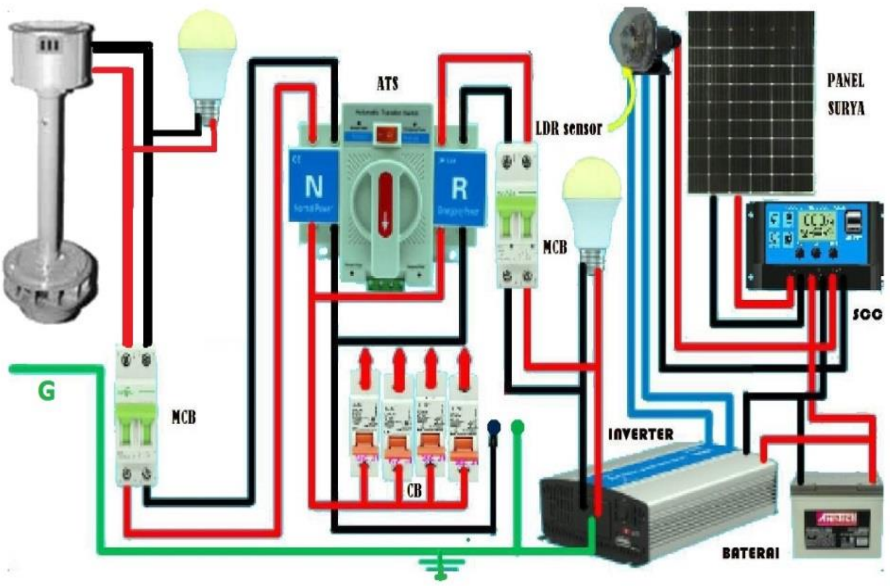


Figure 2. Single line diagram of hybrid power generation system

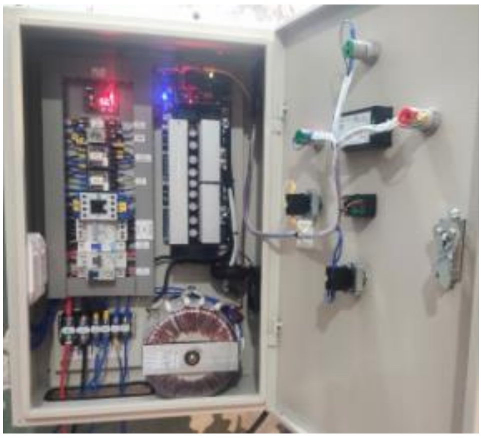


Figure 3. Hybrid generator control box

4. RESULTS AND DISCUSSION

4.1. Load Data

Table 1. Load Data

No	Device	Unit of Power (W)	Amount	Total Power (W)	Duration (hours()	Total (Wh)
1	Lamp	20	9	180	12	2160
2	Lamp	10	4	40	12	480
3	Street Lamp	15	2	30	12	360
4	Garden Lamp	15	4	60	10	600
5	Refrigerator	130	1	130	24	3120
6	Show Case	250	1	250	12	3000
7	Rice Cooker	180	1	180	5	900
8	Television	100	1	100	5	500
9	Sound System	300	2	600	10	6000
Total Power Usage (Wh)						17120

4.2. Results of voltage, current, and power measurements on the solar power system

Table 2. Data collection of solar power system day 1

No	Time	Voltage (V)	Current (A)	Power (Watt)	Condition
1	10.00	13,88	2,13	29,5	Cloudy
2	11.00	15,93	5,81	92,5	Clear
3	12.00	18,72	6,34	118,6	Clear
4	13.00	14,86	1,09	16,1	Cloudy
5	14.00	14,08	3,13	4,4	Rainy

Table 3.

Table 4. Data collection of solar power system day 2

No	Time	Voltage (V)	Current (A)	Power (Watt)	Condition
1	10.00	13,11	1,05	13,7	Clear
2	11.00	14,49	1,23	17,8	Clear
3	12.00	15,93	6,24	99,4	Clear
4	13.00	15,76	6,83	107,6	Clear
5	14.00	15,11	3,33	50,3	Cloudy

Table 5. Data collection of slar power system day 3

No	Time	Voltage (V)	Current (A)	Power (Watt)	Condition
1	10.00	13,43	2,1	28,2	Cloudy
2	11.00	15,17	2,66	40,3	Clear
3	12.00	15,22	4,17	63,4	Clear
4	13.00	14,31	1,92	27,4	Clear
5	14.00	13,81	6,7	9,2	Cloudy

Table 6. Data collection of Solar power system day 4

No	Time	Voltage (V)	Current (A)	Power (Watt)	Kondition
1	10.00	13,11	2	26,22	Clear
2	11.00	14,36	3	43.08	Clear
3	12.00	16,20	6,83	110,64	Clear
4	13.00	14,31	1,92	27,4	Clear
5	14.00	13,91	6,7	93,19	Clear

Table 7. Data collection of solar power system day 5

No	Time	Voltage (V)	Current (A)	Power (Watt)	Condition
1	10.00	13,43	2,1	28,2	Cloudy
2	11.00	24,82	2,68	66,51	Clear
3	12.00	26,22	4,17	109,33	Clear
4	13.00	14,31	1,92	27,4	Clear
5	14.00	13,81	6,7	92,5	Clear

From the measurement of the solar panel system shows that the system consists of 4 solar panels installed in parallel. This produces varying output power values, 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.

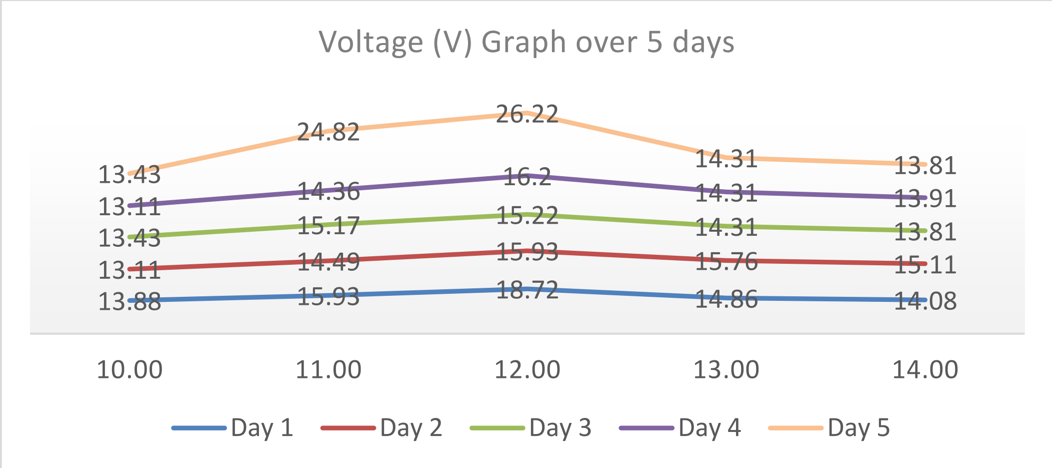


Figure 4. Voltage (V) Over 5 Days

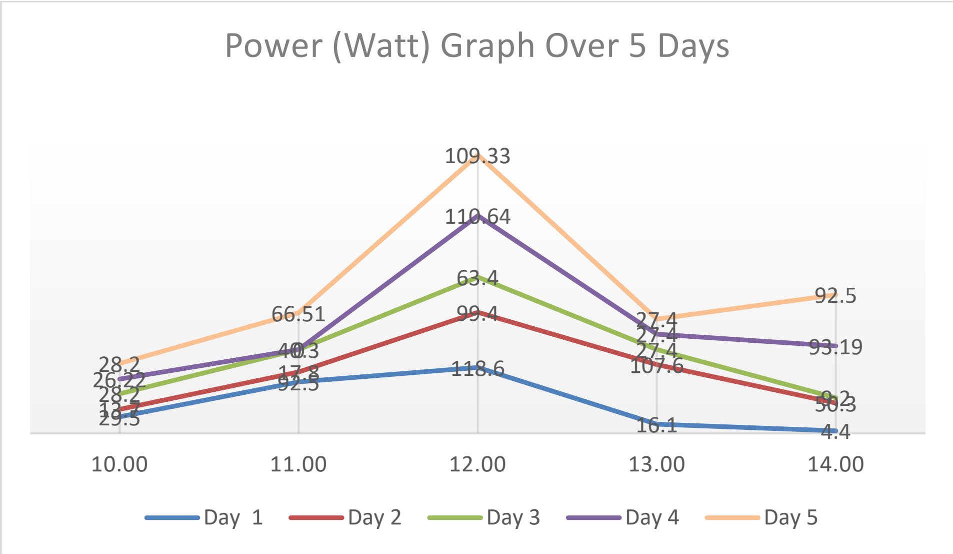
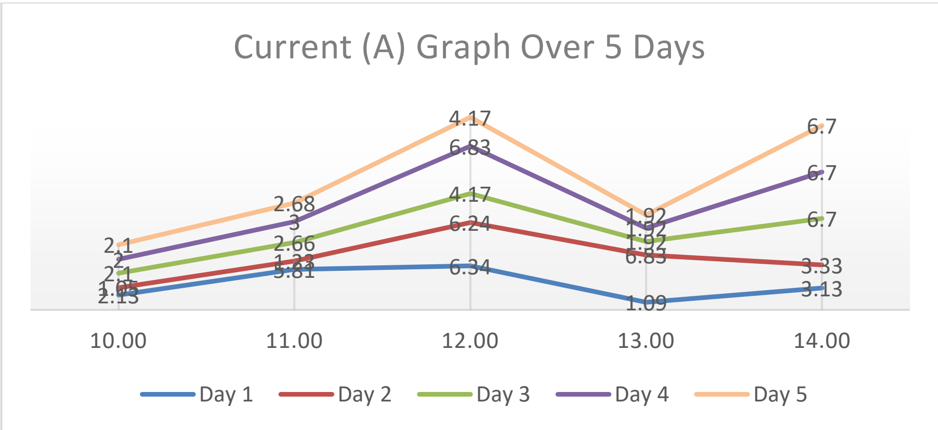


Figure 5. Power (Watt) Over 5 Days



Current (A) Over 5 Days

5. CONCLUSION

From the results of the hybrid model measurements consisting of the designed picho-hydro system and solar panels, the production of electrical energy can be utilized to meet the electrical energy needs of the electrical load of 540 kWh/day, with an average electrical load per hour of 135 kW. The electrical power generated can also be distributed to the network as electrical energy that can be sold to conventional electricity providers, with excess electricity reaching 76% of the power generated by the picho-hydro generator.

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