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Hybrid Water Pump with River Flow and Solar Power for Farmer Groups in Plana Village-Banyumas Central Java

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Abstract— Plana Village located in Somagede District, Banyumas Regency, Central Java Province is about 25 km Southeast of the Universitas Jenderal Soedirman Campus. In this village, a small business group is engaged in freshwater fish farming under the names TIRTA LESTARI and GAPOKTAN PLANA JAYA fish cultivator groups. Based on direct observations, the group uses the Serayu River as the primary water source for their fish ponds. The position of the fish pond is around 10 meters higher than the river flow so the water lifting process is carried out using a water pump. The only solution for providing water is to use a machine-powered water pump. The group complained about this solution because they had to pay operational costs for engine fuel. As a result, the group's profits are not optimized. Considering these conditions, a water pump technology transfer activity with a waterwheel as the driving force is planned to develop the results of research and service carried out in the Physics Department, Faculty of Mathematics and Natural Sciences, Universitas Jenderal Soedirman. The goal of the operations that have been conducted is to address partner concerns regarding the provision of water supplies. Activities aimed at becoming an economically productive partner will prioritize key issues, including the implementation of green energy technology, such as hybrid water pumps powered by solar energy and river flow. The next step involves providing training and counseling sessions for the TIRTA LESTARI agriculture group and the merged PLANA JAYA farming group.

Keywords— Plana, Pump, River, Solar, Waterwheel

I. INTRODUCTION

Plana Village, Somagede District, Banyumas Regency, Central Java is located southeast of Purwokerto, Central Java Province. This location is approximately 27.3 km from the Unsoed Campus via village roads. Since the route passes through several villages in the Somagede District area, with relatively small roads, the travel time from the UNSOED Campus is around 55 minutes. Based on profile data obtained from the population documents of Plana Village, it is known that by the end of 2023, the population will be around 3680 people with an area of 340,646km². From direct interviews with the Head of Plana Village and several of his staff, it is known that in this village several business groups are under the guidance of the Plana Village Government.

The business groups that are currently a priority for the Plana Village Government are the Fish Cultivation Group "TIRTA LESTARI" and the Association of Farmer Groups (GAPOKTAN) "PLANA JAYA". Based on initial observations at this location, it was discovered that the two groups were using land belonging to the Plana Village Government in the same area. In cultivation, both groups utilize water sources from the Serayu River which were previously stored in permanent storage tanks. The tank is also provided by the Plana Village Government for water supply for fish ponds and water supply for crystal guava and longan farming. The position of the fish pond and

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agricultural land is at a height of around 10 meters from the surface of the river flow. The group uses rainwater for irrigation in the rainy season and the flow of the Serayu River in the dry season.

Direct observations and interviews with several core administrators of both groups utilized the permanent pool provided by the Plana Village Government. The permanent pond is used as a water reservoir for irrigating fish ponds and a water supply for cultivating crystal guava. During the rainy season, the pond relatively does not experience problems related to filling the permanent pond, but in the dry season, the group uses a machine-powered water pump to lift water from the Serayu River (Taufiqurrahman & Windarta, 2020). The process of lifting water in the dry season is carried out approximately twice every week, so it requires additional operational costs for engine fuel. As a result, the group's profits are not maximized. The profit target for this group, which was discovered through direct interviews, is around 30% of capital by reducing operational costs for engine fuel.

The main problem experienced by both groups of freshwater fish farmers and crystal guava and longan farmers is water availability. This is because the water supply to the permanent storage tank provided by the Plana Village Government is very low during the dry season. As a result, the availability of water to be supplied to fish farmers' ponds and crystal guava and longan farms is also very low Aryanto, et al.,(2022). This is the main source of problems for both groups because the only solution to supply water from the Serayu River is to use a machine pump. The use of pumps powered by machines was a big complaint for both groups of farmers because they required additional operational costs in the form of renting pumps and fuel to store water in permanent ponds measuring 5 × 35 m with a depth of 70 cm. The height of the permanent pool above the river flow is around 10 m which requires water pump technology that is energy-efficient, cost-effective, and environmentally friendly. After considering the priority problems faced by the two farmer groups, namely, the size of the operations needed for water supply, a solution was planned in the form of transferring green energy water pump technology (Alkarrami et al., 2020).

This activity is a form of transformation of research results that have been carried out previously regarding water pumps with waterwheels as the driving force (Aminuddin et al., 2018). The construction of the wheel connection and several drive wheels on the pump is called an energy converter to convert the energy of the water flow into mechanical energy to rotate all the wheels (Aminuddin, Effendi, et al., 2020). In principle, the energy converter is the same as the wheel system in small-scale hydropower plants (Subekti et al., 2020; Tapia et al., 2021). Research related to the optimization of energy converters, and drive wheel connections has been previously studied for systems for pendulum system ocean wave power plants (Aminuddin, Effendi, et al., 2020; Ningtyas et al., 2023), and small-scale power plants with one turbine turning two electric generators (Rochman & Hermawan, 2022; Wisudanto et al., 2024). All the results of research and services that have been carried out previously will be applied in the process of making energy converters at partner locations (Aminuddin, Effendi, et al., 2020). The pump will be paralleled with a DC pump using solar power (Alkarrami et al., 2020; Wisudanto et al., 2024). This green energy technology has also been applied previously in the Physics Department, FMIPA UNSOED (Aminuddin, Effendi, et al., 2020; Subekti et al., 2020).

II. MATERIAL & METHOD

This section will describe the design and implementation of a hybrid water pump, where the pump design consist of several important components such as a solar cell, charger controller, battery, and DC (Direct Current) load. The hybrid water pump is applied as an irrigation system for agriculture without relying on the power grid.

A. Design of a Hybrid Water Pump

The design and realization of an energy-saving water pump with a wheel as the driving force was previously developed after studying and analyzing the workings of engine-powered and electric-powered water pump drives (Alkarrami et al., 2020; Feliks Eldad Larobu, Yuliadi Erdani, Bahdin Ahad Badia, 2024). Apart from that, the water wheel as the driving force for this pump has also been developed after studying the working principles of water turbines in small-scale hydropower plants to rotate electric generators (Aminuddin, Nurhayati, et al., 2020; Negoro et al., 2024; Tapia et al., 2021). Based on the working principle of turbines for micro-hydro and pico-hydro hydroelectric power plants (PLTA) (Dhiva Pratama et al., 2021; Putraa et al., 2022), the water pump is considered like an electric generator which is rotated through a connection of wheels connected to a turbine which is rotated or driven by the push of water (Aminuddin, Nurhayati, et al., 2020; Tapia et al., 2021). The rotation speed of the wheel and several wheels to rotate the water pump are analyzed based on the radial speed of all the drive wheels used in the converter system (Aminuddin, Effendi, et al., 2020). By utilizing these principles, in this activity, a water pump will be developed with a wheel as the driving force (Alkarrami et al., 2020; Aminuddin et al., 2018; Subekti et al., 2020). In the case of using a pump in a very deep well, it is necessary to use engine power because it requires rotation at a very high speed. For this reason, this activity is only limited to designing pumps to lift water originating from river flows (Phyoe Min Than, Cho Cho Khaing, 2019; Rochman & Hermawan, 2022) . The river flow is used not only as a water source but also as a driving force for pumps. The water pump using a water wheel in previous research was the result of a modification of the jet pump (Aminuddin et al., 2018; Susaidi et al., 2020) and the hydram pump (Anwar et al., 2023; Hartadi et al., 2024; Jafri et al., 2020; Johanis et al., 2023). Figure 1 shows a schematic of a water pump with river flow and a waterwheel as the driving force.

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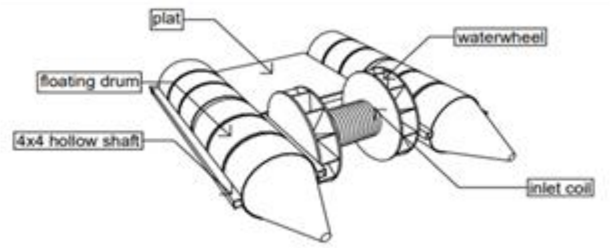

Figure 1. A water pump scheme with the river flow and waterwheel as the driving force for a hydram model has been developed at the Physics Department, FMIPA Unsoed

A water pump driven by river flow to rotate the wheel is installed in a hybrid manner with a DC pump driven by solar power (Alkarrami et al., 2020) . Solar energy is an alternative energy source that can be used as electrical energy (Alkarrami et al., 2020). A solar panel is a device that can convert solar energy into electrical energy (Aminuddin, Effendi, et al., 2020). The average solar energy potential in Indonesia reaches 4.8 kWh/m2. A solar power plant used to drive a DC pump has previously been successfully realized by researchers from the Physics Department, FMIPA UNSOED. The pump is capable of lifting well water from a depth of 15 m (Aminuddin et al., 2018; Rochman & Hermawan, 2022).

A solar cell is a device that can convert solar energy radiation into electrical energy (Aminuddin, Effendi, et al., 2020). The material that makes up solar cells is a semiconductor. The amount of electrical energy produced by a solar cell is determined by the efficiency of the solar cell, its surface cross-sectional area, and the intensity of light received by the solar cell. The intensity of sunlight in sunny weather conditions can reach 1000 W/m2. A series of solar cells can be combined in series or parallel to form a solar panel. Combining solar cells into a solar panel aims to obtain the desired electrical energy. A solar panel device has an efficiency of 10%, so a 1 m2 solar panel will produce 100 Watts of energy (Alkarrami et al., 2020; Wisudanto et al., 2024). Electrical energy requirements can be calculated based on the water pump energy used. The water pump installed has a power of 180 Watts with a voltage of 12 volts DC. A water pump of this size requires an electric current of 15 A when connected to a current source with a voltage of 12 V. When the water pump starts, it requires at least 150% of the average power (Alkarrami et al., 2020; Subekti et al., 2020). Thus electricity must be provided with a minimum power of 270 watts. This amount of electrical energy needs can be met by installing 2 solar panels with a power of 150 WP connected in parallel. A schematic of a solar water pump is shown in Figure 2 (Subekti et al., 2020; Wisudanto et al., 2024).

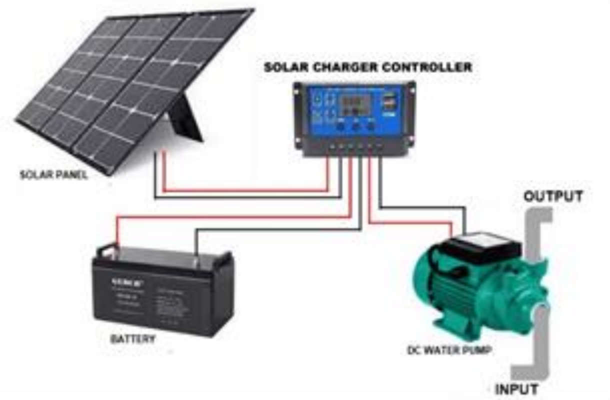

Figure 2. Solar water pump schematic

B. Application of a Hybrid Water Pump

The application of a hybrid pump between water flow and solar power requires special knowledge and skills (Amanda & Fitria, 2023). For this reason, a special strategy is needed to maintain the sustainability of this technology implemented by partners. Table 1 shows a summary of the implementation stages based on the sequence of activities, problems and solutions, activity stages, and the role of partners.

Table 1. Summary of activity stages

Problems and solutions	Activity Stages	The role of partners
Problem: Water supply from the Serayu River requires large costs with machine pumps. **Solution:** Using water pumps is energy-efficient, cost-effective, and environmentally friendly	**Socialization:** Measurement of potential river flow and potential solar radiation at partner locations. **Training:** The training was carried out in the form of a Forum Group Discussion between partners and the Plana Village Government. **Application of technology:** Hybrid installation of water pumps powered by river flow and solar power **Mentoring and evaluation:** - Assistance to partners in the practice of operating and maintaining hybrid water pumps. -Evaluation of the performance of the hybrid water pump in the form of calculating the	Assist in the preparation and implementation of initial measurements of river flow potential and solar power potential -Assist in the preparation and installation process of the hybrid water pump -Maintain and maintain the continuity of the pump

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	energy and water flow produced. **Program sustainability:** The Plana Village Government is willing to make it on a large scale with the assistance of the implementation team.	

In the initial stage, this activity was carried out by analyzing the ability of the Serayu River flow conditions to be used as a water source and a source of thrust to rotate the wheel. Apart from that, measurements of the intensity of solar radiation will also be carried out to determine the potential energy produced at partner locations. The balance of the thrust force will be studied to rotate the wheel as an energy converter (Aminuddin, Effendi, et al., 2020). The energy converter is an important part of the pump to convert river flow energy into mechanical energy to drive the pump to lift the Serayu River flow to a permanent reservoir.

At the socialization stage, activities continued by analyzing the ability of the Serayu River flow conditions to be used as a water source and a source of thrust to turn the wheel. Apart from that, measurements of the intensity of solar radiation will also be carried out to determine the potential energy produced at partner locations. The balance of the thrust force will be studied to rotate the wheel as an energy converter (Aminuddin, Effendi, et al., 2020). The energy converter is an important part of the pump to convert river flow energy into mechanical energy to drive the pump to lift the Serayu River flow to a permanent reservoir .(Aminuddin et al., 2018; Phyoe Min Than, Cho Cho Khaing, 2019)

The stages of implementing technology, especially the installation and maintenance of hybrid water pumps powered by river flow and solar power (Wisudanto et al., 2024), will be carried out at separate times. This policy was taken because it requires special expertise in the water pump installation process. Technology transfer activities in the form of direct practice in the field will be carried out at the same time.

At the assistance and evaluation stage, specifically for solutions involving the installation of water pumps, partner assistance is carried out in the form of practical operation and maintenance of hybrid water pumps (Subekti et al., 2020). Evaluation is carried out on the performance of the water pump in the form of calculating the energy and water flow produced by this system. Assistance for this activity is carried out specifically in a separate time.

1. Religious tourism is worship
2. Religious tourism is closely related to the development and dissemination of knowledge, such as the fifth pillar of Islam, namely the Hajj and Umrah to the Baitullah.
3. Making da'wah an important goal of the journey of Islamic teachings, such as visiting graves or seeing the new moon during the month of Ramadan.
4. Traveling is also a way to reminisce, including giving thanks for the beauty of nature, contemplating the greatness of Allah SWT's creation, and increasing faith during tourism activities.

C. Cultural Tourism Concept

Cultural tourism is a means for people from outside the region to come to tourist attractions that are triggered by asking for historical relics and customs of ancient people. Cultural tourism also includes cultural elements such as cultural heritage, community traditions, and religious practices (Khotimah et al., 2017).

Koentjaraningrat in Herawati (2010) said that culture can be described in three ways, namely as complex behavior, as a concept of an order of values and as a product of human effort.Cultural tourism refers to something that has attraction, beauty and value in the form of natural, cultural and human diversity (Maisyani et al., 2022). Table 2 shows the Variables for the Concept of Spiritual Experience in Religious and Cultural Tourism

The spiritual experience of cultural tourism involves traveling beyond borders to explore and understand the culture of a tourist destination(Sukaatmadja et al., 2017). Tourists who are involved in religious ceremonies can experience values, including:

1. Respecting the diversity of beliefs of local communities,
2. Self-reflection and
3. Search for deeper meaning.

Table 2. Variables for the Concept of Spiritual Experience in Religious and Cultural Tourism

No	Spiritual Experience Concept		
	Variable	Religion	Culture
1	Worship	✔	
2	Science	✔	
3	Preaching	✔	
4	Tadabur	✔	
5	Diversity		✔
6	Self reflection		✔
7	Search for Meaning		✔

III. RESULTS AND DISCUSSION

The sustainability of this activity has been guaranteed by the supervisor of both groups (Plana Village Government) in the form of providing continuous assistance facilities. The hybrid pump in this activity will only realize the system on a small scale. For sustainability, the Plana Village Government is willing to provide funding facilities for hybrid pumps on a larger scale to produce water flows according to the needs of both groups. The development of hybrid pumps on a large scale will receive assistance from the FMIPA UNSOED Physics Department team.

The water pump developed was named the Archimedes Spiral pump. The Archimedes Spiral Pump, also known as the Archimedes screw or Archimedes water screw, is an ancient device used to move water from low places to higher places. This tool was discovered by

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Archimedes around the 3rd century BC. This pump consists of a spiral tube placed at an inclined angle. When the spiral is rotated, water or other liquid is captured between the spiral coils and moves upward as the spiral rotates. This process allows water to be moved from lower to higher areas, usually used for irrigation (Aminuddin, Nurhayati, et al., 2020; Subekti et al., 2020). The shape of the pump in question is shown in Figure 3.

Figure 3. The water pump resembles Archimedes' spiral.

Energy conversion in a solar panel system is a process where energy from sunlight is converted into electrical energy. This process involves several important components, and the conversion occurs through a circuit that includes a solar cell, charge controller, battery, and DC (Direct Current) load. When sunlight hits a solar cell, the energy from these photons is transferred to electrons in the semiconductor material. This energy sets the electrons free and creates an electric current. This flow of electrons produces DC in the circuit, the basic form of electrical energy solar panels produce. The DC electric current is controlled with a power meter to see the current, voltage, and power produced to see the average power produced in one day of exposure. The DC electric current produced by the solar panels flows to the solar charge controller (SCC). Then from the SCC, the DC is charged to the 50 AH LiFePo4 battery. SCC functions as a charge controller to ensure that the battery is not overcharged and discharged excessively, thereby extending battery life and preventing backflow from the battery to the solar panel at night. The electrical energy in the battery is used to power the load in the form of a DC pump to fill water into the tower and push the water to the storage pool. The output from the 50 AH LiFePo4 battery is connected to a 12 Volt Relay to stabilize the load coming from the battery and SCC (Alkarrami et al., 2020; Jafri et al., 2020; Johanis et al., 2023; Phyoe Min Than, Cho Cho Khaing, 2019; Wisudanto et al., 2024). The design of a solar water pump is shown in Figure 4.

Both pumps are implemented in hybrid mode at partner locations to be used as a source of water supply to permanent storage tanks. The installation of these two pumps in a hybrid manner aims to maintain the continuity of water supply for the TIRTA LESTARI and GAPOKTAN PLANA JAYA fish farmer groups. The design of field conditions for the installation of these two pumps is shown in Figure 5.

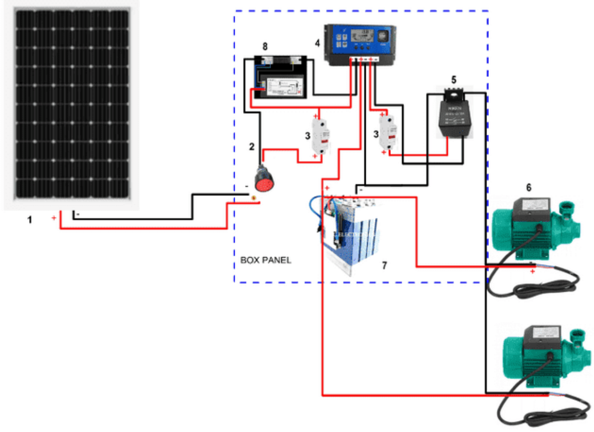

Figure 4. Solar water pump construction.

Figure 5. Design of field conditions at partner location for installing hybrid water pumps.

Spiral water pumps do not perform optimally due to fluctuating river flow conditions, leading to increased interest in solar water pumps. A significant finding from recent activities is that during the rainy season, a backup pump is unnecessary, as agricultural land water needs are sufficiently met by rainwater (Darmawan et al.,2023) . As a result, the local government has planned to implement solar-powered water pumps on a larger scale. Measurements indicate that the solar water pump can completely fill a reservoir with a capacity of 2000 liters in just 106 minutes. This means the pump has an average water lifting capability of 18.87 liters per minute. In comparison, the Archimedes spiral water pump can only lift water at a rate of 0.85 liters per minute. Consequently, it can be concluded that the solar water pump operates 22.20 times more effectively than the Archimedes spiral water pump. In the future, the Archimedes spiral water pump will likely be used only in river flow areas with limited solar radiation. Figure 6 shows the spiral Archimedes pump installation in the river flow.

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Figure 6. The spiral Archimedes pump installed in Plana River close to the pump with solar panel.

Figure 7 illustrates the process of installing a solar water pump. Based on previous information, the operational costs for providing water to fish ponds and agricultural land are calculated every two days of the week. Each day, 10 liters of diesel fuel are required, priced at IDR 6,800 per liter. This results in a daily fuel cost of IDR 68,000. The pump machine used is owned by the Plana Village government, so there are no rental costs associated with the equipment. However, the cost of hiring a skilled operator to run the pump is necessary. The operator's wage is IDR 75,000 per day. If we consider an average of 8 operating days per month, the monthly operational costs during the dry season amount to IDR 1,744,000. Over the 6 months of the dry season, total operational costs are projected to be IDR 10,464,000. During these 6 months, both groups were able to sell their harvests of catfish, guava, and watermelon for a total of around IDR 15,000,000. This results in a profit of IDR 5,000,000 for both groups from water sharing. With the introduction of solar-powered water pumps, future operational costs can potentially be eliminated. As water circulation remains necessary for the fish ponds, these costs can be temporarily reduced by 50%, resulting in a savings of approximately IDR 5,232,000. The success of this initiative is primarily evidenced by its production outcomes.

Figure 7. Installation of solar water pump.

In this activity, we initially planned to address two aspects: production and management. A summary of the activity's success is presented in Table 3.

Table 3. Changes resulting from service activities

Initial Condition	Intervention	Condition Change
Using water pumps is energy-efficient, cost-effective, and environmentally friendly.	A hybrid water pump that combines river flow power and solar power has been successfully developed.	The pump can continuously discharge up to 2,000 liters of water in 106 minutes.
Group Management Development in Water Management	Guidance on managing water discharge, particularly during the dry season.	The community is capable of regulating and maintaining water pumps, particularly those powered by solar panels

IV. CONCLUSION

The successfully constructed pump is a hybrid system that combines solar and river flow power. However, both partners are not particularly interested in the river flow component because it requires further protection. Instead, they are focusing more on solar-powered pumps. Water pumps that run on solar energy are economical, environmentally friendly, and energy-efficient. This pump can discharge up to 2,000 liters of water in just 106 minutes.

The sustainability of this activity has been guaranteed by the supervisor of both groups (Plana Village Government) in the form of providing continuous assistance facilities. The hybrid pump in this activity will only realize the system on a small scale. For sustainability, the Plana Village Government is willing to provide funding facilities for hybrid pumps on a larger scale to produce water flows according to the needs of both groups. The development of hybrid pumps on a large scale will receive assistance from the Department Physics team of the Faculty of Mathematics and Natural Sciences, Universitas Jenderal Soedirman.

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